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THE

TWENTIETH

ANNUAL REPORT

OF THE

MARYLAND

Agricultural Experiment Station,

COLLEGE PARK

PRINCE GEORGE'S CO., MARYLAND.

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1906–1907.

PUBLISHED BY THE STATION.

— THE —

Maryland Agricultural Experiment Station.

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The Board of Trustees of the Maryland Agricultural College.

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ALLEN P. DAVIDSON	*Clerk.*

*On State Horticultural Department Work.

The Station is located on the B. & O. R. R. and City & Suburban Electric Car Line, eight miles north of Washington, D. C.
Bell Telephone—Hyattsville 4 R.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station in all of its departments.

The Bulletins and Reports of the Station will be mailed regularly, free of charge to all residents of the State who request it.

ADDRESS:
AGRICULTURAL EXPERIMENT STATION,
College Park, Maryland.

LETTER OF TRANSMITTAL.

To His Excellency, Edwin Warfield,

Governor, and President of the Board of Trustees,

Annapolis, Md.

Sir:—In accordance with the provisions of Section No. 3, of the Act of Congress, approved March 2, 1887, "To Establish Agricultural Experiment Stations," etc., I have the honor to transmit the Twentieth Annual Report of the Maryland Experiment Station for the fiscal year ending June 30, 1907.

Very respectfully yours,

H. J. PATTERSON,

July, 1907. Director of the Experiment Station.

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THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Volume 20. 1906-1907.

Report on the Work and Expenditures of The Maryland Agricultural Experiment Station.

FOR THE YEAR ENDING JUNE, 1907.

BY H. J. PATTERSON, Director.

To the Honorable Board of Trustees of the
Maryland Agricultural Experiment Station.

GENTLEMEN:—I again have the honor and privilege of presenting my annual report concerning the work, condition and needs of the institution under your charge.

The past year has marked a broadening of the scope of the work of the Station, and a general increase in its activities, which it is hoped will have an important bearing upon the agriculture of our State. The continued approval of the Station's efforts by the agricultural public is a reasonable assurance that our work is regarded as helpful.

The condition of the Station and its equipment is in the main gratifying and satisfactory to the Station workers; yet it is to be said that this institution is relatively in its infancy, and still in the process of development, and therefore real needs exist, which must be supplied if there is to be progress in efficiency and completeness of equipment and organization.

STATION STAFF.

The policy adopted by your board during the past year with reference to the graduation of the salaries of Station officers and assistants, will certainly be a great help in the procuring and holding of desirable investigators, and the placing of the work on a higher and more staple basis. This policy will also do much toward maintaining the interest of farmers in our work, and in inspiring their confidence.

CHANGES IN STATION STAFF.

During the past year the following changes in Station staff have occurred:

Mr. William N. Hutt, who had served as horticulturist for two years, resigned November 1, 1906, to accept a similar position in North Carolina. This vacancy was filled by the appointment of C. P. Close, M. S., who entered upon his duties January 1, 1907. Mr. Close graduated at the Michigan Agricultural College in 1895. After graduation he spent some time in practical horticultural work in Michigan and California, and was assistant horticulturist at the Geneva (N. Y.) Station and horticulturist of the Utah and Delaware Stations.

Mr. P. M. Novik, of Cornell University, was appointed to the new assistantship in horticulture, and entered upon his duties in August, 1906.

The position of Dairy Husbandman, which had been vacant for some months, was filled September 1, 1906, by the appointment of Mr. C. W. Melick, a graduate of the University of Nebraska.

The position of Assistant Poultryman was filled December 1, 1906, by the appointment of Mr. C. L. Opperman, of Cornell University, who had also been connected with the poultry departments of the Michigan and Iowa Experiment Stations.

January 1, 1907, Mr. W. T. L. Taliaferro discontinued his work with the Experiment Station, so as to devote all his time to the College work. This vacancy was provided for by the appointment of V. M. Shoesmith, B. S., a graduate of the Michigan Agricultural College in 1901, and who had been Associate Agronomist at the Kansas Experiment Station since graduation.

Mr. E. O. Garner, who had filled the position of Superintendent of the Farm and Labor efficiently and very satisfactorily for eight years, resigned January 1, 1907. Mr. Garner's resignation was prompted by his desire to return to his family and farm in Carroll County, and his feeling that the duties of the position here were too arduous for a man of his years. This resignation was accepted by the board with much regret, and the position filled by the appointment of Mr. E. H. Brinkley, who had occupied this same position previous to Mr. Garner's appointment.

Mr. Raymond Outwater, Assistant Chemist, died February 9, 1907, and this vacancy was filled by the appointment of Mr. L. W. Fetzer, Ph. D., of New York, and a graduate of Munich, Germany.

Mr. M. N. Straughn, who had been with the Station for several years, resigned March 1, to accept a position with the United States Department of Agriculture, in charge of their sweet corn investigation. This vacancy was filled by the appointment of Mr. J. J. T. Graham, a graduate of this College, class of 1906, who will enter upon his duties July 1, 1907.

Mr. O. C. Gibbs, clerk, resigned March 1, to accept a clerkship in the United States Navy Department. This vacancy was filled by the appointment of Mr. Allan Park Davidson, of Carroll County.

The plan adopted one year ago for the division of time of College and Station men has proved satisfactory, and should be continued.

PUBLICATIONS.

The following is a list of the publications issued during the year:

Bulletin No. 110—September, 1906—Investigations on the Liming of Soils, by H. J. Patterson, pp. 1 to 56.

Bulletin No. 111—October, 1906—Oyster Shell Scale, by T. B. Symons, pp. 57 to 70.

Bulletin No. 112—November, 1906—Treating San Jose Scale, by T. B. Symons and A. B. Gahan, pp. 71 to 88.

Bulletin No. 113—December, 1906—Tomato Investigations, by T. H. White and W. R. Ballard, pp. 89 to 112.

Bulletin No. 114—January, 1906—Fertilizer Experiments with Different Sources of Phosphoric Acid, by H. J. Patterson, pp. 113 to 144.

Bulletin No. 115—February, 1907—The Control of Insect Pests and Diseases of Maryland Crops, by J. B. S. Norton and T. B. Symons, pp. 145 to 208.

Bulletin No. 116—March, 1907—Marketing Fruit and Truck Crops, by William N. Hutt, pp. 209 to 257.

Bulletin No. 117—April, 1907—Molasses Stock Feeds, by H. J. Patterson and R. Outwater, pp. 259 to 290.

Bulletin No. 118—June, 1907—Alfalfa Growing in Maryland, by C. W. Nash, pp. 291 to 314.

Bulletins Nos. 110 to 114 have been mailed to the names on the General mailing list; Nos. 115 and 116 to the names on the Horticultural mailing list; Nos. 117 and 118 to the Dairy mailing list.

MAILING LIST.

The growth of the mailing list, though not as rapid as at some times in the past, has continued steadily during the year. The number of names on the list now is as follows:

1.	General List of Maryland Farmers	22,000.
2.	Horticultural List	5,000.
3.	Tobacco Growers' List	3,000.
4.	Creamery Patrons' List	1,000.
5.	Milk Shippers' List	1,000.
6.	Newspapers in Maryland	420.
7.	Agricultural Papers	220.
8.	Libraries	100.
9.	Farmers' Clubs in Maryland	35.

10.	Maryland Granges	60.
11.	Fertilizer Manufacturers	125.
12.	Farmers of Other States	2,000.
13.	Experiment Station Officers and Workers	1,200.
14.	Foreign List	180.

All publications are mailed to the Newspaper, Agricultural papers, Libraries, Experiment Station workers and Foreign lists.

BUILDINGS.

The total amount which this Station has invested in buildings is only about $28,000, which includes four houses for laborers. This is much less than is frequently appropriated in many States for a building for a single department, and less than one-fifth what many States are spending on their main building for use in agricultural investigation or instruction. In general, it would seem to me that the policy of giving money for work, rather than building, when only a limited amount is available, is much wiser than to give money for building without anything to maintain them with. I am convinced that in many cases too much stress has been placed on the value of the building, and not enough upon the character of work being performed. Many of our young men think that elaborate equipments and buildings are absolutely essential for investigations, and are forgetful that some of the greatest scientists have conducted their work in attics and cellars, and some of the most lasting discoveries have been made with home-made improvised apparatus. While mindful of all of these conditions, yet I do appreciate that the public looks for something larger, more elaborate and substantial than is found in most of our structures, and that a good, well-appointed building seems to add dignity to the institution, and aids in commanding respect.

Taking all into consideration, I would recommend that your board take some steps in the near future to provide such buildings as will be required by the development of our work. If it is not possible or feasible to get a large amount at any one time, then to outline a schedule, which can be properly provided for, and to be carried out gradually through a series of years, and thus be able to meet the emergencies in a substantial way, as the work grows.

A scheme for a general agricultural building for both instruction and investigation might be possible, yet would require more outlay at once than the having of one department at a time.

The new barn and green-houses provided for last year are now in course of erection, and will probably be ready for occupancy by the middle of the summer, or early fall.

The hollow cement block-house has been completed, and is proving very satisfactory. It cost about 25 per cent. more than frame construction, but is much more substantial, and presents a nicer appearance.

INVESTIGATIONS.

The investigations which have been completed or advanced sufficiently to make a report of progress on are covered in the list of publications issued during the year.

The following is a list of the investigations being pursued by the different departments:

AGRONOMY.

The work of this deparment was under the direction of Mr. W. T. L. Taliaferro up until January 1, 1907, when he gave up his Experiment Station work, so as to devote his entire time to his College duties. On January 1 this department was placed in charge of Mr. V. M. Shoesmith. The work in progress at present is as follows:

1. Corn Experiments.

(a) Breeding of Leaming and Munnikhuysen Corns, including a plan for the introduction of new blood into the breeding plots.

(b) Testing of the degree of inbreeding or close breeding, which may be safely practiced.

(c) Variety tests; 23 varieties of corn are being grown at present on the Station farm, and co-operative tests with five farmers in different parts of the State.

2. Cow-peas.

(a) A study of the crop with reference to the improvement of the plant for Maryland conditions.

(b) A study of the methods of harvesting and threshing cow-pea seed.

3. Alfalfa Experiments.

(a) Breeding.
(b) Testing seed from different sources.
(c) Fertilizer tests.
(d) Methods of the preparation of seed-beds.
(e) Cutting experiments.
(f) Culture experiments.

4. Clovers—Experiments with Red, Mammouth, Alsike and White Clovers.

(a) Breeding experiments.
(b) Test of seed from different sources.

WHEAT EXPERIMENTS.

(a) Improvement by selection.
(b) Improvement by breeding.

Some preliminary work is being done looking toward the taking up of new lines of work, and plans are being devised for the enlarging of the facilities and equipment for this department, so as to enable the work to be produced and pushed forward with more rapidity.

BOTANICAL DEPARTMENT.

The usual investigations of cases of plant diseases arising from time to time have been made, and information with reference to the same have been given either by personal interviews or by letter. Many weeds and plants have been identified and named for farmers, and numerous samples of seeds tested as to purity and vitality.

Investigations are now in progress on the diseases of clover and alfalfa, and a detailed study is being made of the weeds of the State and methods of destroying the same.

CHEMICAL DIVISION.

The work in this department is mainly a continuation of the investigations outlined in the Eighteenth Annual Report, and caring for the general analytical work of the different departments, and the miscellaneous samples which come in for examination.

DAIRY DIVISION.

The principal work in this division during the year has been confined to a study of physical and chemical constituents which affect the food value of milk and determining just what effect each factor has on digestion.

Some studies have been made on the flavors of milk and the conditions which influence their development.

DEPARTMENT OF ENTOMOLOGY.

The past year, owing to extreme climatic conditions, was rather adverse to the conducting of several experiments that had been previously planned. An attempt will be made to either duplicate or carry out the original plans this year. The following may be stated as the lines of work in progress or planned:

1. An investigation of the life history, habits and most effective means of control of the Peach Scale (Eulecanium Nigro-faciatum).
2. An investigation and study of the green-house pests of Maryland.
3. A study of the life history and experiments with different

treatments for the control of the Scurfy Scale (Chionasphis Furfura).

4. Testing different treatments, and studying the life history of the codling moth (Carpocapsa Pomonella).

5. Testing different mixtures and devices as preventatives for the peach tree borer, in co-operation with the Bureau of Entomology, United States Department of Agriculture.

6. Experiments testing various spray solutions for the San Jose scale.

7. Experiments on fumigation of nursery trees with hydrocyanic acid gas; also testing various strengths of the gas on peach buds.

8. Experiments with different materials for the control of the Woolly Aphis in nurseries.

MOSQUITO WORK.

A mosquito survey of the State has been commenced by this department, but lack of funds has prevented its progress and completion. There is great need in the State for vigorous work in mitigating this dreaded pest.

Not only should efforts be exerted in the low and marshy areas, but also in all the small towns of the State where negligence as to breeding places of the pest abound.

It is pleasing to note here the results of the agitation from many sources on this subject in Baltimore City, in which vicinity most of the work conducted by this department, and published in Bulletin No. 109, of this Station, was done. There is now an ordinance in force requiring that breeding places of the mosquito be destroyed, and a penalty for those persons responsible for neglect. These requirements should be extended to all parts of the State, and this department should be vested with the powers for a rigid enforcement of same.

SPRAYING DEMONSTRATIONS

The conducting of spraying demonstrations in different parts of the State have been found to be producing the best results in arousing interest among farmers to the importance of such practice. While this phase of the work has been as yet confined to treating of orchard trees for the control of the San Jose scale, it is hoped to extend the work in the treatment of injurious insects attacking other horticultural and agricultural crops. Several of the above demonstrations have been conducted the past winter and spring, all of them being well attended by the farmers in the vicinity. The practical work of making and applying a given remedy seems to more forcibly appeal to those present than a verbal description of the operation.

SAN JOSE SCALE.

It is a source of satisfaction to report the decidedly improving condition as regards the infestation of this insect in the majority of orchards in the State. Among the progressive orchardists this insect is now looked upon as one that can be easily controlled by the application of the proper remedies. There are many small orchardists and even large vicinities in some parts of the State where negligence in the control of the insect is very apparent. This is especially true in the small towns of the State. The Osage Orange Hedge is now no doubt a most serious menace in the distribution of the insect. Active measures must be taken by the department in the future, requiring the treatment of such hedges all over the State.

PUBLIC SPRAYER.

The inauguration of a public spraying apparatus by the department this past spring to meet the demands of citizens of the small towns has been very successfully conducted, considering the circumstances under which it has operated. This is probably the first public sprayer ever conducted by a State Department. It was found that a public sprayer can be made self-supporting, when properly conducted, without making excessive charges for work done, and that the same is hailed with much satisfaction by the citizens of small towns, or those who have a small number of trees, requiring treatment.

ORCHARDS AND NURSERY INSPECTION.

The usual amount of inspection of orchards, nurseries, etc., has been conducted, and considerable new territory covered.

HORTICULTURAL DEPARTMENT.

Experimental work in progress January, 1907.

1. Asparagus fertilizers, begun spring 1904; 20 plots, each one-hundredth acre, located south of apple orchard.

2. Permanent sweet potato plots, begun 1902; sweet potatoes planted every year since; three plots, 32' by 67'. (1) Manure lot; (2) nothing; (3) commercial fertilizer, located north of asparagus bed.

3. Series C; 10 plots east of experimental orchard, begun spring 1904; fertilizer tests on vegetables; organic vs. inorganic and stable manure.

4. Experimental apple orchard. Cover crops, begun 1900.

5. Series A; fertilizer tests begun 1902. Com. Fert. vs. manure and green crops. Economic methods of application to vegetables.

6. Series B; fertilizer tests begun 1903 (same as No. 5).

7. Block 6; variety test gooseberries and currants.

8. Block 7; variety test raspberries and blackberries.

9. Strawberry mulching test, begun 1901 (Block 4, 1907).

10. Variety test strawberries, plot by Director's house.

11. Orchard back of President Silvester's house, planted 1897. Varieties of apples, dwarf and standard pears.

12. Vineyard, south of College. Variety test and training exp., begun 1903.
13. Variety plum orchard, south of College. Planted 1903.
14. Variety cherry orchard, south of College. Planted 1903.
15. Variety apples, crab apples and nuts, south of College. Planted 1903-1905.
16. Orchard for student work, planted 1902. Variety applies, with variety as fillers.
17. Apple orchard, southwest College; four varieties grafted on Paradise, Standard and French stock. Planted 1906.
18. Variety potato tests. Effect of time of harvesting and cold storage on seed.
19. Pear breeding, begun 1905.
20. Strawberry breeding, begun 1898; selection from seedlings.
21. Test of flowering plants, begun 1906.
22. Variety test of tomatoes.
23. Green-house experiments.
    - Rotation of crops, chrysanthemums, lettuce, cucumbers.
    - Solid bed vs. benches.
    - Application of phosphates in different forms as affecting soil continuously used.
    - Test of cover crop soils.
    - Fertilizer in solution for chrysanthemums.
    - Surface vs. sub-irrigation with carnations and lettuce.
    - Carnation breeding; selection from seedlings.
    - Effect of fertilizers on stiffness of stems of carnations, begun 1904.
    - Continuing the vigor of carnations by cuttings made from side shoots, main branches and piped cuttings.
    - Fertilizers on violets.
    - Soil and fertilizers for primulas.
    - Variety test of geraniums.
24. Crops for young orchards, E. P. Cohill's, Hancock, Md.
25. Variety peach orchard, E. P. Cohill's, Hancock, Md.
26. Variety peach orchard, W. F. Allen's, Salisbury, Md.

NEW WORK OF 1907.

1. Introduction of the hardiest of the Persian walnuts for Maryland. A survey of the present status of walnut growing in the State, with a view of publishing a bulletin on this subject next winter.

2. Spraying with different strengths of Bordeaux mixture on apples at the Experiment Station and at E. P. Cohill's.

3. Apple Breeding, to originate a variety earlier than any we now have, especially a red variety. Also to obtain a very late good quality red apple.

4. Pear breeding.

Planting a dwarf pear and dwarf apple orchard for the plant-breeding work.

6. Growing of forestry seedlings.

7. Growing mushrooms; a list of varieties and different kinds of spawn; also different times of spawning the same house.

8. Cultivation of artichokes.

9. Introduction and improvement of the paw-paw.

10. Introduction of timber trees from California.

11. New raspberry plantations; test distances apart of planting and pruning and training.

12. Treatment of soils with fertilizers and otherwise, as affecting late cabbage.

13. Effect of fertilizers on the structure of plants.

14. Copper sulphate on plants; can copper sulphate in very weak solution cause a plant to become immune to disease.

15. Determining the life of apple pollen.

16. Rooting apple cuttings.

17. Gooseberry and currant commercial fertilizers vs. hog manure.

18. Variation in plants by excess of food fertilizers in various forms.

19. Test of blight-proof muskmelons.

20. Tests of foreign vegetable seeds and potatoes.

POULTRY INVESTIGATIONS.

This is a new department of the Station, now only about six months old, but one that probably will appeal to more people than any other, for practically every farm and every village and suburban place has some interest in poultry. In the past five years the value of poultry products in Maryland has increased over a million dollars. With this rapid growth has come a demand for information relative to the poultry business in its various phases, such as equipment, incubation, breeding, feeding, etc.

There is much need for some definite, economic information on these points. It certainly is not a good commercial proposition to spend ten dollars for pen for housing, if 75 cents will do just as well. The average loss at present in hatching and raising chickens to a table size represents about 75 per cent. of the eggs set, and makes a chicken, when out of the shell, cost about 12 cents each. Certainly this should not be, and offers an important field for investigation.

During the month of January the Department secured 100 White Leghorn pullets. From this flock over 700 chicks have been hatched, which will be used for experimental work. Several experiments have been planned and outlined, and will be started as early as possible.

The lines of work to be taken up are as follows:

(a) A careful study of the different types of poultry houses, to determine as far as possible which one is best adapted to Maryland's climate. Careful records of the egg production, health of the fowls, amount of food consumed, hatchability of the eggs, etc., will be kept for each separate pen.

(b) Breeding of Barred Plymouth Rocks for egg production.

(c) A series of experiments will be started in the near future to determine, if possible, the reason for low percentage of chicks hatched in machines; also why we find large numbers of fully-developed chicks dead in the shell, etc.

(d) The feeding of different rations for egg production will be carefully studied.

VETERINARY DEPARTMENT.

The scope of the Veterinary Department of the Station was greatly broadened during the year through the allotment of more time and increased facilities for work.

Tuberculosis:—In continuing the work upon tuberculosis and tuberculosis immunization in cattle there have been a number of tuberculosis tests conducted, of which the same shows interesting results. In a lot of five registered cattle, four (80 per cent.) reacted; in a lot of 16 grades principally, eleven (68¾ per cent.) reacted; in a lot of 52 mixed breeds and grades, thirteen (25 per cent.) reacted.

These represented average herds, and it is believed that they show the probable extent of tuberculosis existing among dairy cattle of Maryland.

The condition is serious, as affecting the dairy industry, and as a result of the recent agitation and legislation upon matters of pure food and meat inspection tends to produce an undesirable reaction within the confines of the State. Animals which under old conditions would have found their way to the abattoirs after reaction to the tuberculosis test are now apt to be bartered about, and many eventually return to the dairies for further milk production. This matter has already been noted by the State Board of Health and the State Live Stock Sanitary Board, and they both are alive to the necessity for remedial measures. Our Station should be prepared to assist in this matter as a safeguard both to the public health and to the welfare of the dairy man. It is our function to foster the industry, rather than to depress it, and it appears that we have a double duty and a delicate duty in the matter of tuberculosis regulation.

Tuberculosis in hogs has enormously increased in proportion to the number of creameries established, and cream separators employed on the farms. This has been observed throughout the country, and Maryland is not an exception.

Bovo-vaccinations have been made at eight different farms in the State, upon sixty-seven calves ranging from two weeks to six months of age. No ill effects have been observed from its use in any case, and while our experiences have been for too short a time to draw proper conclusions, yet all preliminary work completed is highly encouraging. Two Bovo-vaccinated animals are being subjected to a test to prove the duration of immunity after two years has elapsed since treatment, and test will be concluded in a few weeks.

Leucoencephalitis in horses appeared in three sections of the State during the year. No advances were made in determining the cause of the disease, but this was really the first opportunity offered since the report on the disease was published, to confirm the work published in that report. The results of post-mortem examinations at each of the three sections visited fully confirms the work previously done, and, further the lesions there described are constant in all cases dying with this disease.

A careful and thorough trial of anti-streptococcic serum was made with negative results in every case.

Milk Studies:—Leucocytes and pus cells in milk, together with milk production studies in general, have been made during the year.

The Doane-Buckley method of enumeration of cells in milk was carefully worked over, and with very slight modifications gave the most consistent results in comparison with other recommended methods.

Quite a number of features developed in the course of this work, which made contradictory the accepted theories of milk production and composition. An interesting field is open for further work.

CO-OPERATION AND DEMONSTRATION EXPERIMENTS.

The following lines of work are being conducted in co-operation with the United States Department of Agriculture.

1. Alfalfa experiments.
2. Wheat breeding.
3. Sugar corn breeding.
4. Study of the effects of environment on the sugar contents of sweet corn.
5. Tobacco investigations.
6. Preventatives for the peach tree borer.
7. Study of the effects of different crop rotations on the maintenance of the fertility of the soil.

In addition to the work being done in co-operation with the United States Department of Agriculture considerable work is in progress in different parts of the State in co-operation with farmers. This work has been covered in the outlines given under the different departments.

FINANCIAL CONDITION.

As appears from the report of the Treasurer the finances of the Station are in good condition, and the year's work has been carried on within the funds available, and small balances remain. It has been the general policy of this institution to run on practically a cash basis, and contract no debts that cash was not on hand to meet at once. All bills are settled in full at close of each month, and where discounts are allowed for cash in five to ten days they were availed of.

With the improvements in the character of work of all of the departments, and the general expansion which has been taking place during the past year, the expenses have increased very materially. The increased cost of labor and all materials has also added considerable to the usual calls for money. While larger amounts of money could be efficiently and profitably used, it is felt that the constituency of the Station should be given convincing evidence that the increase with which we were favored by the last legislature is being used to good advantage before asking for any further endowment. Consequently, it is recommended that the legislature be asked to continue the appropriation received during the past two years for the next two, and this will be absolutely necessary to continue our poultry investigations, and provide for the printing of our bulletins in as large editions as are required to meet the demands.

HATCH FUND.

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

Dr.

1907.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1907, as per Act of Congress March 2, 1887..............$15,000 00

Cr.

1907.

June 30, By	Salaries	$7,774 95
“	Labor	2,386 40
“	Publications	976 24
“	Postage and Stationery	326 09
“	Freight and Express	194 83
“	Heat and Light	475 71
“	Chemical Supplies	21 95
“	Seeds, Plants and Sundry Supplies	418 96
“	Fertilizers	262 50
“	Feeding Stuffs	349 55
“	Library	289 49
“	Tools, Implements and Machinery	516 04
“	Furniture and Fixtures	107 95
“	Live Stock	462 50
“	Traveling Expenses	229 51
“	Contingent Expenses	31 58
“	Buildings and Repairs	175 75
	Total	$15,000 00

The above is a true copy from the books of this office.

(Signed) JOSEPH R. OWENS,

Treasurer Maryland Agricultural Experiment Station.

ADAMS FUND.

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

Dr.

1907.

June 30, To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1906, as per Act of Congress March 16, 1906..........$7,000 00

Cr.

1907.

June 30,	By Salaries	$3,871 96
	" Labor	849 25
	" Postage and Stationery	16 78
	" Chemical Supplies	318 60
	" Seeds, Plants and Sundry Supplies	73 86
	" Feeding Stuffs	362 00
	" Library	26 77
	" Tools, Implements and Machinery	54 11
	" Furniture and Fixtures	12 00
	" Scientific Apparatus	966 93
	" Traveling Expenses	97 74
	" Buildings and Repairs	350 00
	Total	$7,000 00

The above is a true copy from the books of this office.

(Signed) JOSEPH R. OWENS,

Treasurer Maryland Agricultural Experiment Station.

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE STATE OF MARYLAND APPROPRIATION.

1906.	Dr.	
June 30,	To Cash Balance	$4,303 17
1907.		
June 30,	Receipts from the State of Maryland for the fiscal year ending September 30, 1906	$5,000 00
		$9,303 17
1907.	Cr.	
June 20,	By Repairs to Buildings	$1,038 59
"	Insurance	367 31
"	Publications	1,554 57
"	Exhibits	1,030 57
"	Feeding Experiments	1,942 65
"	Tobacco Experiments	78 36
"	Poultry Investigations	2,971 69
"	Demonstration Work	315 91
"	Balance	3 52
	Total	$9,303 17

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE STATION FARM.

1906.	Dr.	
July 1,	To Balance	$21 41
1907.		
June 30,	To Sales of stock and produce since July 1, 1906	6,344 22
		$6,365 63
1907.	Cr.	
June 30,	By Labor	$ 3,171 78
"	Freight and Express	$ 229 04
"	Seeds, Plants and Sundry Supplies	662 61
"	Feeding Stuffs	2,000 00
"	Live Stock	295 00
"	Contingent Expenses	6 00
"	Balance	1 20
		$5,182 63

The above is a true copy from the books of this office.

(Signed) JOSEPH R. OWENS,

Treasurer Maryland Agricultural Experiment Station.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 110. SEPTEMBER, 1906.

RESULTS OF EXPERIMENTS ON THE LIMING OF SOILS.

By H. J. Patterson.

PREFACE.

The experiments reported upon in this bulletin are a continuation of those given in Bulletin No. 66, issued six years ago. This will make the final report upon these experiments as the land used in these tests is no longer available for use by the Experiment Station.

In addition to the discussion of the results of the experiments there will be appended to this bulletin some general information on liming soils and the analyses of the lime and limestone made at this Station. Some of this matter was given in Bulletin No. 66; but as the supply of this bulletin was exhausted several years ago and the demand for the information still continues it has been considered advisable to repeat and supplement it at this time.

Experiment No. 1.

The Results of Applications of Lime on the Yields of a Common Crop Rotation.

This experiment was commenced in the spring of 1893 and results of the progress reported in Bulletins Nos. 56 and 66. The object of the experiment was to note the effect of lime on a rotation of crops, consisting of corn, wheat, and timothy and clover for two years.

There were two plots, containing one-fourth acre each, used in this experiment. Plot No. 1 received two applications of lime in the thirteen years during which the test ran. The first application, of twenty bushels of stone lime per acre, was made in the spring of 1893 previous to planting the land to corn, and the second application of twenty-five bushels of shell lime per acre was made in the spring of 1897. Plot No. 2 received no lime. The treatment of the two plots in all other respects was exactly the same.

The following commercial fertilizers and manure were applied to these plots; each plot receiving exactly the same quantity. At the last cultivation of the corn on July, 1897, crimson clover was seeded. This made a fair stand and growth. It was plowed under as a green manure on May 28th, 1898, and the land worked down and then harrowed from time to time during the summer preparatory to seeding the plots to wheat on September 29th, 1898. There were 400 lbs. of commercial fertilizer per acre applied at the time of seeding the wheat. The fertilizer was made up as follows:

Dissolved Phosphate rock,	1200	Pounds.
Bone tankage, (10%)	400	"
Nitrate of soda,	100	"
Muriate of potash,	300	"
Total	2000	"

This would average approximately as follows:

Phosphoric acid,	9¾%
Nitrogen,	2 %
Potash,	7½%

The plots were plowed December 9th, 1901, for the corn crop of 1902, and on March 26th, the land was top-dressed with stable manure at the rate of ten tons per acre. This manure was worked into the land in May with the "Cutaway" harrow.

The corn was harvested and removed from the land October 8th, and the land seeded to wheat October 27th, 1902. The delay in seeding was caused by wet weather and the low wheat yields may largely be attributed to this late seeding. The following fertilizer was drilled in at the time of seeding the wheat:

Dissolved phosphate rock,	1400	Pounds.
Dried fish,	300	"
Nitrate of soda,	100	"
Muriate of potash,	200	"
Total	2000	

This analyzed approximately as follows:

Phosphoric acid,	10 to 11%
Nitrogen,	2%
Potash,	5%

Corn was planted in rows three feet, nine inches apart and one stalk each fifteen inches in the row.

Wheat was seeded at the rate of six pecks per acre. Timothy was seeded in the fall at time of seeding the wheat at the rate of six (6) quarts per acre and clover in the spring at the rate of six (6) quarts per acre.

Results of Experiment No. 1.

The results of this experiment are set forth in detail in Table I. Page 4. It will be noted that crops were removed from the piece of land each year except in 1898; when a crop of crimson clover was grown and turned under as green manure. The crop of hay for 1904 was harvested and was a fairly good crop, but the weights were lost through an accident, consequently cannot be given; but it is quite certain that they would not materially change the results or the conclusions.

In estimating the relative gains produced by the lime, the following values were placed on the crops: Corn at 40 cents per bushel; Corn fodder 20 cents per Cwt.; Wheat at 90 cents per bushel; Straw at 20 cents per Cwt., and Hay at 50 cents per Cwt.

In the estimate the hay from the limed and unlimed plots were rated as being of equal value, but in fact the hay from the unlimed plot was of very much poorer quality than that from limed plot.

It will be noted in every case that the limed plot gave a better yield than the unlimed one and that the average net return was $4.50 per acre per year. While this may seem to be small at first, yet when applied to a 100 or a 150 acre farm it would mean from $450. to $600. more for each farm annually.

This certainly should impress all persons farming land that requires lime with the desirability, in fact, the necessity of its use. If only one-fourth of the cultivated land in Maryland would show a similar response to the use of lime it would make possible an annual increase in the net returns from the farms of over five millions dollars.

TABLE I.

Yield, Relative Gains and Profits per Acre of Limed and Unlimed Plots.

(Size of plots, one-fourth acre—Duration of Experiment 1893 to 1905).

CROP AND YEAR.	Plot 1. Limed.		Plot 2. Not Limed.		Gains as a Result of Liming.				
					Yields.		Value of Increase.		
	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain bu.	Hay or Fodder lbs.	Grain.	Hay or Fodder.	Total.
Corn, 1893........	21.4	2200	15.8	1792	5.6	408	......	......	......
" 1897........	43.6	2015	26.0	1475	17.6	540	......	......	......
" 1902........	57.0	5900	43.0	5080	14.0	820	......	......	......
Total, 3 Crops Corn	122.0	10115	84.8	8347	37.2	1768	$14.88	$3.54	$18.42
Wheat, 1894*.....	31.3	......	22.8	......	8.5	......	......	......	......
" 1899......	31.4	1014	22.5	768	8.9	246	......	......	......
" 1903.....	7.3	1040	4.7	756	2.6	284	......	......	......
Tot'l 3 Crops Wheat	70.0	......	50.0	......	20.0	530	$18.00	$1.06	$19.06
Hay, 1895.........	......	2662	......	1391	......	1271	......	......	......
" 1896.........	......	756		360	......	396	......	......	......
" 1900.........	......	2000	......	960	......	1040	......	......	......
" 1901.........	.....	2440	......	1780	......	660	......	......	......
" 1905.........	......	2300	......	1820	......	480	......	......	......
Total, 5 Crops Hay†	......	10158	......	6311	......	3847	......	......	$19.23

Total profit on 11 crops......................................	$56.71
Cost of lime, 2 applications, (45 bushels)........................	7.20
Net profit..	49.51
Profit per crop per acre......................................	4.50

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*Yield of straw not recorded.

†Yield of 1904 hay crop lost.

EXPERIMENT NO. 2.

Testing the Lasting Effects of Different Quantities of Lime.

This experiment was commenced the spring of 1896. A report of progress of the experiment was made in Bulletins Nos. 46, 56, and 66. The land used in this test is a portion of College Park subdivision and is situated adjoining and east of the Pike and north of College Avenue. This piece of land is a stiff clay, and inclined to wet. Previous to its use for this experiment this land had not been cultivated for a number of years, and was very unproductive. The only growth on the land for years was a scanty growth of dewberry vines, sedge grass, and golden-rod. Very little vegetable matter had accumulated owing to the custom of annually burning off the tract.

The land was plowed in the spring, and the lime, which was slacked by means of water to a powdery condition was applied by means of a shovel and immediately harrowed into the soil. The rotation on these plots consisted of corn with wheat seeded in the fall in the corn stubble and timothy and clover seeded in the wheat and allowed to stand for hay one year.

The corn was planted in rows three feet, nine inches apart and one stalk each fifteen inches in the row. Wheat was seeded at the rate of six pecks per acre, with six (6) quarts of timothy per acre at the time of seeding the wheat and six (6) quarts of clover seed per acre in the spring. Aside from the difference in the quantities of lime applied the plots were treated in all other respects exactly alike. There was no fertilizer applied to the corn, but commercial fertilizer was drilled in with the wheat. Each plot received the same quantity of fertilizer.

For the 1897 wheat crop there was 600 lbs. of fertilizer used per acre
" " 1900 " " " " 400 " " " " "
" " 1903 " " " " 300 " " " " "
" " 1905 " " " " 400 " " " " "

The fertiizer used in 1900, 1903, and 1905 was made up as follows:

Dissolved phosphate rock,	1400	Pounds.
Tankage,	400	"
Nitrate of soda,	100	"
Muriate of potash,	100	"
Total	2000	

The formula used in 1897 was:

Dissolved phosphate rock,	1000	Pounds.
Tankage,	500	"
Nitrate of soda,	200	"
Muriate of potash,	300	"
Total	2000	

Results of Experiment No. 2.

The results in detail are set forth in Tables II to VII. In estimating the gain and relative profits the same values were placed upon the crops as those given in Experiment No. 1, Page 3. The results all show a marked advantage from the use of lime and give a net return that confirms the results set forth in Experiment No. 1, Page 3. In general the results covering the whole period of eleven years (see Table VII), favor the use of the larger quantities of lime, but the net returns from the larger quantities are not proportionately greater than those with the smaller quantities. In other words twenty bushels gave only about twenty-five per cent. more net profit than ten bushels instead of twice as much, as might be expected and sixty bushels only about fifty per cent. more instead of six times as much. From this it might be concluded that while the greatest profit would come from the use of fairly large quantities of lime, yet if only so much could be invested in lime that it would be better to put sixty bushels on six acres rather than on one acre and allow the five to go without. A study of Tables II to VII show that the effect of the application of ten bushels and twenty bushels of lime per acre showed approximately the same relative yearly increase throughout the whole period of eleven years, and in this respect acted just about the same as the fifty or sixty bushel applications, instead of showing a marked falling off or exhaustion as might have been expected.

TABLE II.

Showing the lasting effects of different quantities of Lime on the Yields of Corn.

(Yields per Acre.)

Plot No.	Quantity of Lime, bu.	1896.		1899.		1902.		1905.		Totals—4 Yrs.	
		Grain, bu.	Fodder,* lbs.	Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder,* lbs.
1	10	23.9	......	35.2	1845	31.8	1724	34.5	2359	125.4	5928
2	20	25.6	......	28.5	2070	33.2	1969	31.1	2541	118.4	6580
3	No lime	17.4	......	30.5	1845	27.1	1860	22.2	2399	97.2	6104
4	30	25.8	......	34.8	2160	33.8	1815	30.4	2359	124.8	6334
5	40	27.1	......	36.5	2025	37.3	1815	35.1	2184	136.0	6024
6	No lime	15.3	......	23.4	1755	25.4	1679	21.7	2269	85.8	5703
7	50	28.8	......	39.8	2115	40.9	1997	34.7	2399	144.2	6511
8	60	29.8	......	42.4	2295	46.1	1815	37.5	2359	155.8	6469

*Yield of fodder in 1896 not recorded, as a strong wind storm blew some of the shock together and badly mixed them.

TABLE III.

Showing cost of Lime and value of gains from 4 Crops of Corn, per acre.

Plot No.	Quantity of Lime, bu.	Cost of Lime.	Value of Gains.*		
			Grain.	Fodder.	Total.
1	10	$ 1.80	$13.56	0.05	$13.61
2	20	3.60	10.76	1.35	12.11
3	No lime	....	....	....	....
4	30	5.40	13.32	0.86	14.18
5	40	7.20	17.80	0.24	18.04
6	No lime	....	....	....	....
7	50	9.00	21.08	1.22	22.30
8	60	10.80	25.72	1.13	26.85

*Corn valued at 40 cents per bushel and fodder at 20 cents per cwt.

TABLE IV.

Showing the lasting effects of different quantities of Lime on Yields of Wheat.

(Yields, per acre.)

Plot No.	Quantity of Lime, bu.	897.		1900.		1903.		1906.		Total, 4 Crops.	
		Grain, bu.	Straw,* lbs.	Grain, bu.	Straw, lbs.	Grain, bu.	Straw, lbs.	Grain, bu.	Straw, lbs.	Grain, lbs.	Straw, lbs.
1	10	26.0	......	15.2	1940	4.2	648	11.0	1143	56.4	3731
2	20	27.7	......	22.8	4380	4.7	576	11.3	990	66.5	5946
3	No lime	22.5	......	10.8	1180	3.0	360	6.2	612	42.5	2152
4	30	28.7	......	20.5	1880	4.7	576	9.0	675	62.9	3131
5	40	31.9	......	22.4	2560	7.3	864	8.4	936	70.0	4360
6	No lime	22.7	......	11.5	1580	3.4	603	7.4	594	45.0	2777
7	50	31.0	......	24.0	2450	9.0	900	5.6	1017	69.6	4367
8	60	32.5	......	20.1	2750	8.4	936	9.2	891	70.2	4577

*Weight of straw not recorded.

TABLE V.

Showing cost of Lime and value of gains from 4 Crops Wheat, per acre.

Plot No.	Quantity of Lime, bu.	Cost of Lime.	Value of Gains.*		
			Grain.	Straw.	Total.
1	10	$ 1.80	$11.43	$2 53	$13.96
2	20	3.60	19 52	4.96	24.48
3	No lime	....	....	....	....
4	30	5.40	17.28	1.33	18.61
5	40	7.20	23.67	3.79	27.46
6	No lime	....	....	....	....
7	50	9.00	23.31	3 81	27.12
8	60	10.80	23.85	4 23	28.08

*Grain valued at 90c. per bushel and straw at 20c, per cwt.

TABLE VI.

Showing the lasting effects of different quantities of Lime on Yields of Hay and value of gain per acre.

Plot No.	Quantity of Lime, bu.	Hay, 1898, lbs.	Hay, 1901, lbs.	Hay, 1904, lbs.	Total Hay, 3 crops.	Gains, lbs.	Value of Gain.
1	10	2502	2610	990	6102	2457	$12.28
2	20	2367	3060	1125	6552	2907	14.53
3	No lime.	972	2070	585	3627	....	....
4	30	2205	2880	1305	6390	2745	13.73
5	40	2322	2835	1485	6642	2997	14.98
6	No lime.	1053	1890	720	3663	....	....
7	50	2133	2610	1485	6228	2583	12 42
8	60	2286	2790	1665	6741	3096	15.48

TABLE VII.

Summary of relative profits obtained with different quantities of Lime all Crops (11 crops.)

Plot No.	Quantity of Lime, bu.	Cost of Lime.	Corn gain on 4 crops.	Wheat gain on 4 crops.	Hay gain on 3 crops.	Tota gain.	Relative profits with 11 crops.
1	10	$1.80	$13.61	$13.96	$12.28	$39.85	$38.05
2	20	3.60	12.11	24.48	14.53	51.12	47.52
3	No lime.	....	....	....	....	....	....
4	30	5.40	14.18	18.61	13.73	46.52	41.12
5	40	7.20	18.04	27.46	14.98	60.48	53.28
6	No lime.	....	....	....	....	....	....
7	50	9.00	22.30	27.12	12.42	61.84	52.84
8	60	10 80	26.85	28.08	15.48	70.41	59.61

EXPERIMENT NO. 3.

Testing the Value of Green Manure in Connection with Lime.

The land used for this experiment was of the same general character and contiguous to the plots used in testing the different quantities of lime. It was divided into two plots of equal size. They were plowed and prepared for seeding May 12th, 1896, when stone lime was applied to plot No. 2 at the rate of forty bushels per acre. On May 13th, both plots were seeded to cow peas at the rate of five (5) pecks per acre without fertilizer. The difference in the growth of the peas on the two plots was quite apparent; both the color and density of the growth being in favor of the plot securing the lime. The peas on both the plots was plowed down August 24th. On October 2nd, they were

In this connection it is of interest to note the results covering the first four years of the experiment as given on Page 126 of Bulletin No. 66, which was as follows:

TABLE VIII.

Value of Gains Produced Per Acre With Different Quantities of Lime.

(In Dollars and Cents.)

Plot No	Quantity of Lime, bu.	Value of Lime, $	Value of Gain of Corn at 30 cts. bu., 1896.	Value of Gain of Wheat at 90 cts. bu., 1897.	Value of Gain of Hay at 50 cts. cwt., 1898.	Value of Gain of Corn, 1899.		Total Value of Gains.	Relative Profits From Gains.
						Gain at 40 cts. bu.	Fodder at 20 cts. cwt.		
1	10	1.80	2.28	3.06	7.45	3.28	0.09	16.16	14.36
2	20	3.60	2.79	4.59	6.78	4.60	0.54	19.30	15.70
3	No lime	....	....	....	....	....	....	....	....
4	30	5.40	2.85	5.49	5.97	3.12	0.72	17.97	12.57
5	40	7.20	3.24	8.37	6.55	3.80	0.45	22.41	15.21
6	No lime	....	....	....	....	....	....	....	....
7	50	9.00	3.75	7.56	5.60	5.12	0.63	22.66	13.66
8	60	10.80	4.05	8.91	6.37	6.16	0.99	26.48	15.68

The above table presents the results so clearly that it is almost useless to say anything further than to call attention to the fact that small applications of lime have proven to be as efficient at the end of four years as the larger application, and that the relative profits, up to date, are in favor of applying twenty bushes per acre.

From this we may conclude that small and frequent applications are probably preferable to large applications.

seeded to wheat and from that time on the plots were treated alike and the same rotation followed as with the plots receiving the different quantities of lime.

In Table IX is given the yields of those plots in ten years, together with the average of the "No Lime" plots for comparison and in Table X the relative profits resulting from their use.

The same prices were placed upon the respective crops in calculating the value of the grains as were used in Table I.

The results obtained in this experiment are decidedly in favor of using lime in combination with the green manure, (peas). The result no doubt would have been more marked in favor of the combination if more green manure could have been introduced at different times during the rotation.

TABLE IX.

Yields, per acre, resulting from the use of Cow Peas and Lime as Soil Improvers and Renovaters.

CROP AND YEAR.	No Lime.		Cow Peas, No Lime.		Cow Peas and Lime.	
	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain, bu.	Hay, Fodder or Straw, lbs.
Wheat, 1897	22.6	....	32.4	....	34.0	....
" 1900	11.2	1380	14.2	1550	22.5	4320
" 1903	3.2	482	4.2	693	6.0	585
" 1906	6.8	603	6.9	846	7.1	1602
Total, 4 crops Wheat	43.8	2465	57.7	3089	69.6	6507
Hay, 1898	....	1012	....	1062	....	1638
" 1901	....	1980	....	1980	....	2610
" 1904	....	652	....	765	....	865
Total, 3 crops Hay	....	3644	....	3807	....	5113
Corn, 1899	27.0	1800	22.8	1215	27.0	1845
" 1902	26.2	1770	26.4	1951	31.4	1679
" 1905	21.9	2334	22.8	2541	32.0	2399
Total, 3 crops Corn	75.1	5904	72.0	5707	90.4	5923

TABLE X.

Relative profits from the use of Cow Peas alone and Cow Peas and Lime in combination as Soil Improver.

	Corn.		Wheat.		Hay.	Totals and Relative Profits.
	Grain.	Fodder.	Grain.	Straw.		
Increased yield caused by cow peas	(—3.1 bu)	(—197 lbs.)	13.9 bu.	624 bu.	163 lbs.	
Value of increase	(— $1.24)	(—$0.20)	$12.51	$1 25	$0.81	$13.13
Cost of growing crop peas						5.75
Net profit in 10 years from use of peas						$ 7.38
Average profit per year or crop						0.74
Increased yield caused by peas and lime	15.3 bu.	19 lbs.	25.8 bu.	4042 lbs.	2069 lbs.	
Value of increase	$6.12	$0.04	$23.22	$8.08	$10.35	$47.81
Cost of peas and 40 bushels lime						12.95
Net profit in 10 years from use of peas and lime						34 86
Average profit per year or crop						3.48

EXPERIMENT NO. 4.

Testing the Value of Stable Manure in Combination with Lime.

In 1902 there was inaugurated an experiment to test the value of the use of stable manure in comparison with lime, also to determine the effects of using lime in combination with manure.

The land used for this experiment was contiguous to that used for Experiments Nos. 2 and 3, pages 5 and 9, and was of the same general character. The plots were cropped and treated the same as in the two preceding experiments.

The plots were plowed in December, 1901, and the manure applied April 30th, 1902, and worked into the land with a cutaway harrow and then the lime was applied on May 3rd as a top-dressing and incorporated with the soil with a harrow previous to planting to corn. The plots received only one application of manure and lime.

The results in detail are given in Tables XI and XII, and show very conclusively in favor of the use of both lime and manure, and decidedly in favor of using them in combination. The net profits per year from the use of twelve tons of manure and twenty bushels of lime per acre are greater than has been obtained in any of the other lime tests and are in a measure an explanation for the better crops which are obtained in those sections of the State that have used lime and manure extensively for generations.

TABLE XI.

Yields per acre resulting from applications of Lime and Stable Manure.

(Size of plots 30x60, or 4800 sq. ft.

Crop and Year.	No Lime.		20 bushels Lime.		12 tons Yard Manure.		12 tons Yard Manure and 20 bu. Lime.	
	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain, bu.	Hay, Fodder or Straw, lbs.	Grain, bu.	Hay, Fodder or Straw, lbs.
Corn, 1902................	26.2	1770	33.2	1969	57.1	3405	65.3	3267
" 1905............ ..	21.9	2334	31.1	2541	49.9	3220	66.3	2995
Total 2 crops corn......	48.1	4104	64.3	4510	107.0	6625	131.6	6262
Wheat, 1903..............	3.2	482	4.7	576	5.8	234	9.0	982
" 1906..............	6.8	603	11.3	990	9.2	1071	10.5	1017
Total 2 crops wheat	10.0	1085	16.0	1566	15.0	1305	19.5	1999
Hay, 1904	......	652	......	1125	......	1980	......	2610

TABLE XII.

Showing increase, value of increase and relative profits from the use of Lime and Stable Manure.

	Corn.		Wheat.		Hay.	Totals and Relative Profits.
	Grain.	Fodder.	Grain.	Straw.		
Increased yield caused by 20 bushels lime	16.2 bu	406 lbs	6.0 bu.	481 lbs.	473 lbs	
Value of increase	$8.48	$0.81	$5.40	$0.96	$2 36	$18.01
Cost of 20 bushels lime						3.60
Net profits from the use of 20 bushels lime						$14.41
Net profits per year or crop						2.88
Increased yield caused by 12 tons manure	58.9 bu.	2521 lbs	5.0 bu	220 lbs.	1328 lbs.	
Value of increase.	$23.56	$5.04	$4.50	$0.44	$6 64	$40.18
Cost of 12 tons manure						12.00
Net profits from use of 12 tons manure						$28 18
Net profits per year or crop						$5.64
Increased yield caused by lime and manure	83.5 bu.	2158 lbs.	9.5 bu.	914 lbs.	1958 lbs.	
Value of increase	$33.40	$4.32	$8 55	$1.83	$9 79	$57.89
Cost of 20 hushels lime and 12 tons manure						15.60
Net profits from applications						$42.39
Net profits per year or crop						$8.48

EXPERIMENT NO. 5.

Comparing the Value of Different Sources of Lime and Ways of Applying the Same, Together with the Physical Effect of Some Other Materials.

With a view of studying the effects of different kinds of lime, and different modes of applying the same lime, also of endeavoring to test if the land was responding to lime as a plant food or only needing chemical and physical changes, the following series of experiments were outlined and entered upon in the spring of 1895. The land used in this test is a nice sandy clay loam, well drained, and would be considered of a nice character for general farming and truck crops. It is probably a little light for grain and grass, but a good tobacco and potato soil.

This piece of land was planted in cherry trees in 1889 and kept cultivated, but not cropped in the meantime. Many of the cherry trees had died out, and the remaining ones had made but little growth, so they were pulled out. For this test the land would permit of plots only ten feet wide and sixty-seven feet long with a two foot space between each plot. This gave the plots practically one sixty-fifth of an acre each. The plots were plowed May 24th, 1895, and lime was applied on May 25th. This is the only application of lime which was made.

The following table gives the application on which was made to each plot. The quantities applied in the case of lime were such as to give each plot the same quantity of Calcium Oxide, which was determined by analysis. Plots are numbered from tobacco barn toward the south.

Lime Experiments.

(Size of plots, 10x67 feet, with 2 feet space.)

Plot No.	Description of Application.	Quantity per acre, lbs
1	Stone Lime (Calcium Oxide-CaO). Fresh slaked and applied as a top dressing, not harrowed into the soil........	1400
2	Stone Lime (Calcium Oxide-CaO). Freshly slaked and harrowed into the soil immediately........................	1400
3	Oyster Shell Lime (Calcium Oxide)CaO). Freshly slaked and thoroughly worked into soil immediately............	1400
4	Oyster Shell Lime (Calcium Oxide-CaO). Worked into the soil before slaking..................................	1400
5	Magnesium Oxide (MgO), worked into the soil with harrow.	1400
6	Barium Oxide (BaO), worked into the soil with harrow....	1400
7	Nothing.....	
8	Shell marl (Calcium Carbonate ($CaCO_3$), worked into the soil with harrow..	13000
9	Finely ground oyster shells (Calcium Carbonate, ($CaCO_3$)..	2600
10	Land Plaster, Gypsum (Calcium Sulphate,) ($CaSO_4$).......	4125
11	Gas Lime	2925
12	South Carolina Rock, finely ground (Calcium Phosphate) $Ca_3(PO_4)_2$..	2925
13	Soft Coal Ashes..	13000
14	Complete Com. Fertilizer. { Double Superphosphate..200 Tankage.................100 Sulphate of potash....... 80 }	380

The rotation on the plots consisted of corn, wheat, and timothy and clover. There was a crop of crimson clover seeded in the corn in 1895, at the last working, and this was plowed under in the spring of 1896 for that year's corn crop. The corn crops of 1899 and 1903 and all of the wheat crops received an application of commercial fertilizer. The fertilizer, cultivation, etc., of all the plots was uniform throughout the experiment.

Results of Experiment No. 5.

The yields obtained as a result of the various applications are classified according to the crop and given in detail in Tables XIII to XV, and a summary of them in Table XVI. From these results the following conclusions may be drawn:

As to Method of Applying Lime.

1. The difference is not great, but slightly in favor of having the lime incorporated with the soil before slacking. This confirms the theory that the greatest chemical and physical effect should be procured by this system.

2. That the lime should be incorporated with the soil immediately upon application rather than put on as a top-dressing.

Comparison of Stone and Oyster Shell Lime.

3. The yields show a slightly greater increase from the use of oyster shell lime than from stone lime, although the difference is not very marked. See results on stone lime plots one and two, and oyster shell lime plots three and four.

Comparison of Pure Lime (Ca O) With Magnesium Lime (Mg O.)

4. The results show that magnesium oxide (lime) produced decidedly better yields of grain than the pure limes, though not quite as much forage. While it would not often be economical or practical to use pure magnesium lime, yet these results prove that magnesium is not poisonous to crops as is commonly believed. (Compare the yields of plots 1, 2, 3 and 4 with plot 5).

Comparison of Lime (Ca O) Magnesium Oxide (Mg O) and Barium Oxide (Ba O).

5. Barium oxide was used in this experiment to determine what physical effect it might have, as it in no wise acts as direct plant food, or could be considered as such. A study of the results of plot No. 6,

and comparing them with those of the preceding plots it will be noted that the Barium oxide did not seem to have the lasting effect that the lime and Magnesium had, but that it produced a decided increase in the yields in the early years and not much in the later years. It seemed to have more effect in increasing the forage part of the crop than the grain. These results would seem to give a strong indication that the effect of the lime was more due to its chemical and physical action than to being a direct plant food.

Comparison of Caustic Lime (Ca O) with Carbonate of Lime (Ca CO 3).

6. On comparing the yields of plots 8 and 9 with plots 1, 2, 3 and 4, it will be noted that the carbonate of lime gave decidedly better results than the caustic lime. The only reason that can be offered for this result is that the soil being acid, liberated carbonic acid which was absorbed by the soil water and gave this water a greater dissolving action on other plant foods than it had previously with the other acids. Again, the chemical and physical action produced in the presence of carbonic acid may have been very different from that produced by the caustic lime. These results are particularly interesting as they have a decided bearing on the conditions found throughout the tide-water section of the State and the application of these results would make the application of lime available in lots of sections, which are not using any now and which would benefit greatly by its use.

Results of Use of Maryland Marl.

7. It is particularly desirable to call special attention to the increased yield produced by the shell marl applied to plot No. 8. The marl used in this experiment was procured at Seat Pleasant in Prince George County, and was of about the composition represented by sample No. 587, Table XXV, page 53. It will be noted that the application of shell marl produced more grain and forage than either stone lime or oyster shell lime; in fact the marl plot produced more pounds of crop than any lot in the series. Shell marl is very abundant in many parts of Southern Maryland and the Eastern Shore and it should be used locally more largely than it is. All farmers who have access to deposits of shell marl should use it extensively and depend on it as their source of lime rather than purchasing caustic lime.

Comparison of Land Plaster (Ca SO 4) with Caustic Lime (CaO).

8. A comparison of the yields of plot 10 with those of plots 1, 2, 3 and 4 shows decidedly in favor of the use of caustic lime. The cost of application of the caustic lime was only about one-fourth as much as of the gypsum. These results show nothing to recommend the use of plaster.

COMPARISON OF GYPSUM ($Ca\ SO_4$) AND FINELY GROUND OYSTER SHELLS ($Ca\ CO_3$).

9. The yields obtained on plots 9 and 10 show very decidedly in favor of the use of finely ground oyster shells over gypsum. Their cost per ton is about the same and much less of the shells was used.

COMPARISON OF GAS LIME AND OYSTER SHELL LIME.

10. The comparison of the yields of plots 3 and 4 with those of plot 11, which received gas lime of oyster shell origin, shows quite conclusively in favor of the caustic lime rather than the gas lime. Gas lime is frequently purchased with the idea that it is very cheap, but when it is considered that gas lime is slacked lime which has absorbed a great deal of water and other impurities the relative cost is more than is at first apparent.

THE USE OF PHOSPHATE OF LIME.

11. The phosphate of lime in the form of finely ground raw phosphate rock produced a decided effect. The yield obtained with it was much better than with gypsum, but not so good as with either carbonate or caustic lime.

SOFT COAL ASHES.

12. The soft coal ashes produced little, if any, effect; certainly no increase of yield.

TABLE XIII.

Showing the effect of different sources of Lime on the yields of Corn per acre.

Plot Number.	Application.	Corn, 1895.		Corn, 1896.		Corn, 1899.		Corn, 1903.		Total 4 crops.	
		Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder, lbs.	Grain, bu.	Fodder, lbs.
1	Stone Lime (CaO), slaked and applied as top dressing..........	42.7	2308	29.5	1950	17.5	4875	38.1	2308	127.8	11441
2	Stone Lime (CaO), slaked and harrowed into soil..............	43.1	2113	34.4	1900	10.7	4550	39.5	2665	127.7	11228
3	Oyster Shell Lime (CaO), slaked and harrowed into soil........	40.4	2145	38.5	2275	13.9	3900	37.1	3120	129.9	11440
4	Oyster Shell Lime (CaO), harrowed into soil before slaking....	41.9	2080	36.3	2145	11.5	5200	37.6	3088	127.3	12513
5	Magnesium Lime (MgO)	38.8	2210	34.4	2047	23.5	3250	43.6	2990	140.3	10497
6	Barium Oxide (BaO)...	36.8	2080	35.3	1852	12.7	4875	21.8	1885	106.6	10692
7	Nothing................	35.6	1950	27.8	1885	7.6	3900	26.5	2665	97.5	10400
8	Shell Marl, carbonate of lime ($CaCO_3$).........	42.0	2011	42.7	2112	19.4	4550	40.9	3185	145.0	11858
9	Finely Ground Oyster Shells, carbonate of lime ($CaCO_3$).........	48.8	2044	47.6	2535	22.3	5135	29.7	3120	148.4	12834
10	Land Plaster or Gyysum, sulphate of lime ($CaSO_4$)..............	40.9	2470	26.5	2145	15.1	3575	22.3	2210	104.8	10400
11	Gas Lime....	40.5	2178	27.8	1852	16.7	4550	18.2	1885	103.2	10465
12	Raw Phosphate Rock, phosphate of lime $Ca_3(PO_4)_2$................	38.5	2113	34.5	2242	9.0	4225	29.3	2340	111.3	10920
13	Soft Coal Ashes.........	35.3	1950	24.1	1722	10.7	3775	28.8	2535	98.9	9982
14	Complete Commercial Fertilizer	34.1	2011	20.4	1527	21.9	3900	22.8	2437	99.2	9875

TABLE XIV.

Showing the effects of different sources of Lime on the yields of Wheat per acre.

Plot No.	Application.	Quantity, lbs.	Wheat, 1897.		Wheat, 1900.		Wheat, 1904.		Total, 3 Crops.	
			Grain, bu.	Straw, lbs.	Grain, bu.	Straw, lbs.	Grain, bu.	Straw, lbs.	Grain, bu.	Straw, lbs.
1	Stone Lime (CaO), slaked and applied as top dressing........	1400	15.7	1202	13.0	1495	2.2	812	30.9	3509
2	Stone Lime (CaO), slaked and harrowed into soil............	1400	16.8	1397	13.0	1105	3.8	1105	33.6	3607
3	Oyster Shell Lime (CaO), slaked and harrowed into soil........	1400	14.6	1300	14.0	725	3.3	942	31.9	2967
4	Oyster Shell Lime (CaO), harrowed into soil before slaking.	1400	17.3	1527	14.0	1040	4.3	975	35.6	3542
5	Magnesium Lime (MgO).......	1400	20.0	1786	17.3	1560	2.2	1072	39.5	4418
6	Barium Oxide (BaO)..........	1400	16.8	1527	11.9	910	3.8	812	30.3	3249
7	Nothing......................	.....	14.6	1462	14.0	455	3.3	780	31.9	2697
8	Shell Marl, Carbonate of Lime ($CaCO_3$)	13000	22.2	1917	16.3	1625	4.9	1202	43.4	4744
9	Finely Ground Oyster Shells, carbonate of lime-($CaCO_3$)..	2600	22.2	1690	16.3	1300	3.8	1105	42.3	4095
10	Land Plaster or Gypsum, sulphate of lime-($CaSO_4$)........	4125	15.1	1527	13.0	1170	2.2	780	30.3	3477
11	Gas House Lime...............	2925	17.3	1690	16.3	975	1.6	1072	35.2	3737
12	Raw Phosphate Rock, phosphate of lime-$Ca_3(PO_4)_2$............	2925	17.9	1527	14.6	1742	2.7	845	35.2	4114
13	Soft Coal Ashes................	13000	13.4	1105	11.9	1235	1.6	520	26.9	2860
14	Complete Commercial Fertilizer	380	9.8	1105	9.8	1365	1.6	487	21.2	2957

TABLE XV.

Showing the effects of different sources of Lime on the yields of Hay per acre.

Plot No.	Application.	Quantity, lbs.	Hay—1898, lbs.	Hay—1901, lbs.	Hay—1902, lbs.	Hay—1905, lbs.	Total—4 Crops, lbs
1	Stone Lime (CaO), slaked and applied as top dressing............	1400	1560	1300	780	1950	5590
2	Stone Lime (CaO), slaked and harrowed into soil..................	1400	2535	1625	1300	1300	6760
3	Oyster Shell Lime (CaO), slaked and harrowed into soil...........	1400	2405	1950	2405	1300	8060
4	Oyster Shell Lime (CaO), harrowed into soil before slaking..........	1400	2665	1820	1105	1625	7215
5	Magnesium Oxide (MgO)..........	1400	2210	2600	325	1300	6435
6	Barium Oxide (BaO)..............	1400	1820	2340	715	1300	6175
7	Nothing	......	1365	1625	910	1300	5200
8	Shell Marl, carbonate of lime ($CaCO_3$)	13000	2925	2730	975	1950	8580
9	Finely Ground Oyster Shells, carbonate of lime ($CaCO_3$).........	2600	2600	2275	1105	1950	7930
10	Land Plaster or Gypsum, sulfate of lime ($CaSO_4$).................	4125	1235	2275	780	1300	5590
11	Gas Lime	2925	1495	1690	845	1300	5330
12	Raw Phosphate Rock, phosphate of lime-$Ca_3(PO_4)_2$..................	2925	2145	1560	845	1625	6175
13	Soft Coal Ashes....................	13000	1495	1170	1495	1300	5460
14	Complete Commercial Fertilizer...	380	845	1105	520	975	3445

TABLE XVI.

Summary of the results of the effects of different sources of Lime on Corn, Wheat and Hay.

(Yields per Acre.)

Plot No.	Application.	4 Crops Corn.		3 Crops Wheat.		4 Crops Hay, lbs.	Total, 11 Crops.	
		Grain, bu.	Straw, lbs.	Grain, bu.	Straw, lbs.		Grain, bu.	Forage, lbs.
1	Stone Lime (CaO), slaked and applied as top dressing	127.8	11441	30.9	3509	5590	158.7	20540
2	Stone Lime (CaO), slaked and harrowed into soil....	127.7	11228	33.6	3607	6760	161.3	21595
3	Oyster Shell Lime (CaO), slaked and harrowed into soil	129.9	11440	31.9	2967	8060	161.8	22467
4	Oyster Shell Lime (CaO), harrowed into soil before slaking..................	127.3	12513	35.6	3542	7215	162.9	23270
5	Magnesium Lime (MgO)...	140.3	10497	39.5	4418	6435	179.8	21350
6	Barium Oxide (BaO).......	106.6	10692	30.3	3249	6175	136.9	20116
7	Nothing....................	97.5	10400	31.9	2697	5200	129.4	18297
8	Shell Marl, carbonate of lime ($CaCO_3$).............	145.0	11858	43.4	4744	8580	188.4	25182
9	Finely Ground Oyster Shells, carbonate of lime ($CaCO_3$)	148.4	12834	42.3	4095	7930	190.7	24859
10	Land Plaster or Gypsum, sulfate of lime $CaSO_4$.....	104.8	10400	30.3	3477	5590	135.1	19467
11	Gas Lime................	103.2	10465	35.2	3737	5330	138.4	19532
12	Raw Phosphate Rock, phosphate of lime $Ca_3(PO_4)_2$.	111.3	10920	35.2	4114	6175	146.5	21209
13	Soft Coal Ashes............	98.9	9982	26.9	2860	5460	125.8	18302
14	Complete Commercial Fertilizers	99.2	9875	21.2	2957	3445	120.4	16277

GENERAL RELATION OF LIME TO AGRICULTURE.

Lime was one of the earliest materials used for improving the productiveness of the soil, as is evidenced by the writings of Pliny and Cato. It was used in this way probably two or three hundred years B. C. That chalk and marl were quite extensively used at an early period in Southern Europe is shown by the notes of Varro, taken during the march of his army to the Rhine. The contributions of Ruffin in the "American Farmer" as early as 1818, show that the agricultural use of certain forms of lime took a prominent place in the agriculture of the United States early in its history.

Although lime was thus used early in the history of agriculture, and has been used to a greater or less degree in all parts of the agricultural world ever since, yet the nature of its action on the soil is but little understood and has been but slightly studied. Almost every one recognizes the fact that there is a great difference in the action of lime on soils of different characters. That there is a difference between the action of limes of different character and composition on the same soil is a point seldom noticed.

The term *"lime"* is generally understood to mean quick or caustic lime or Calcium Oxide (CaO). When any form of carbonate of lime; lime-stone, oyster shells, or shell marl, is burned, the carbonic acid is expelled and lime or quick lime is produced. In burning, the Calcium (lime) carbonate ($CaCO_3$) undergoes decomposition, carbonic acid being thrown off, and caustic quick-lime (Calcium Oxide, CaO) remaining in the kiln. The fuels generally used in burning lime are wood, charcoal, coal or coke, and the ashes from these will be found as impurities in the lime.

The kiln may consist of only a crude pile of logs, and wood so arranged as to admit the air and burn freely with the stone or shells piled inside and on top. They may vary in form and construction all the way from this crude type to those constructed of extensive and solid masonry or steel boiler plate lined on the inside with fire-brick, and so arranged that the lime may be perpetually drawn from the bottom while the stone and fuel are being fed at the top. While the types, sizes and details now in use vary considerably, yet the general form most approved is not very different from the description given by Cato. Some limes are burned in retorts, pots or crucibles, thus giving a pure lime, free from the contamination of ashes and unburned fuel.

Lime Burning—Lime-stone or any carbonate of lime begins to decompose at about 300 degrees C., and the temperature usually employed is indicated by a bright red heat. It ought not to exceed 1100 degrees C. The facility with which lime is burned depends upon the porosity and composition of the stone, the size of the lumps and the volume of air passed through the burning mass. Again the expulsion of carbonic acid is facilitated by the introduction of steam into the mass. This is accomplished by practical lime burners by watering lime-stone which has become dry by standing in the open air.

About one bushel of coal is required to make five or six bushels of lime, but dolomitic (Magnesium) lime-stones require less. If much argellaceous matter is present the lime-stone more readily fuses, and in such cases, great care should be exercised to keep the temperature below the melting point, otherwise the mass vitrifies and the lime resulting is said to be "dead burnt" or "over burnt." "Over burning" may also be due to the forming of a half-burnt lime by a strong and sudden ignition, or by means of high temperatures the silica and alumina, contained in the lime-stone, will become sintered over the surface of the lime, forming a slag or glass which prevents its coming in contact with the water and slacking.

From this it will be seen that the same conditions and heats can not be applied to all classes of lime-stones, and that it is necessary to take extra precautions when burning lime-stone of irregular character and composition. In fact it is well not to attempt to burn different veins of lime-stone in the same kiln at the same time. If it is desired to market different grades or veins of lime-stone, and at the same time place only one grade of lime on the market, these should be burned separately and combined after burning. Such a process, if carefully carried out, would prevent much of the trouble in lime slacking unevenly. It is well to have dampers in the kilns, to put the heat under better control.

In burning, lime-stone retains practically the same volume, but loses about 44 per cent. in weight; that is 100 pounds of stone yields about 56 pounds of lime.

Characteristics of Lime:—It is common to hear the terms "Agricultural lime" and "Building lime," used as if these were different articles. In reality, no such difference exists; they are simply trade terms; as the same lime is commonly used indiscriminately for the two different purposes. Sometimes, however, the name "Agricultural lime" is used to mean building lime that has been air or water slacked, and again it refers to the quality of the stone from which it was derived. If it were always thus used the term would have a distinct meaning. Unfortunately it is impossible to define or distinguish a building or agricultural lime even from a chemical standpoint, owing to the fact already stated that different soils respond differently to the same lime and *vice versa*. According to the nature of the lime-stone, it will turn out (a) a fat or rich lime; (b) a poor lime; or (c) an hydraulic lime. If lime-stone consists simply of pure Carbonate of Lime, then the lime obtained therefrom will slack readily, forming a creamy mixture with water, and is called fat or rich lime. On the other hand if the lime-stone contains Magnesia it slacks more slowly, forming a thin, poor mixture and is called a poor lime. With ten per cent. (10 per cent.) of Magnesia a lime is poor, and with twenty-five to thirty per cent. it is almost useless. If the lime-stone contains more than ten per cent. of silica the lime therefrom will have the quality of forming a paste, which will harden under water or in most places where it is not exposed to the drying influence of the air; such lime is known as hydraulic lime. It is very reasonable to suppose that the different limes act differently on the same soil or on soils of different characters, and much in the same manner as they do in forming mortars and cements.

Kinds of Lime Used in Agriculture.

Stone Lime:—Good lime-stone contains from 50 to 55 per cent. lime (CaO), and 40 to 45 per cent. Carbonic Acid, with small amounts of magnesia, silica, iron and aluminia. Such lime, when burnt, would produce the best quality of caustic or quick-lime, and would contain from 90 to 98 per cent. of Calcium Oxide (CaO). Freshly burned lime, when removed from the kiln, will weigh about 90 or 95 pounds to the heaped bushel, and will slack about three bushels for one in volume.

Magnesia Stone Lime:—Magnesia lime-stone, or dolomites are quite varied in their composition, and may range in Carbonate of Lime from 20 to 80 per cent. and in Carbonate of Magnesium from 10 to 60 per cent. The average of such lime-stones used in agriculture, when burned, will produce a lime containing from 70 to 85 per cent. of Calcium Oxide and 5 to 20 per cent. of Magnesium Oxide. Magnesia lime weighs about 75 to 85 pounds to the heaped bushel, and will slack about two bushels for one, by volume.

Oyster Shell Lime:—Oyster shells contain from 90 to 95 per cent. of Calcium (lime) Carbonate, and will produce, when burned, a comparatively pure lime, which should contain from 85 to 95 per cent. of pure Calcium Oxide if it has not been excessively contaminated with impurities and the ashes from the fuel in burning. Freshly burned oyster shell lime weighs about 60 pounds per bushel, and will slake out a little better than two for one by volume.

Slaked Lime:—In the process of slaking lime it takes up water and forms Calcium or Lime Hydrate. It also absorbs some Carbonic Acid from the air and forms Carbonate of Lime. If different samples of lime or slaked lime are in equally good condition they may be thus compared:—

Kind of Lime.	Wt. per bu. before slaking.	Total wt. after slaking.	Number bu. after slaking.	Wt. per bu. after slaking.
Good Stone Lime	93 lbs.	135	3	45
Magnesia Stone Lime	80 "	110	2	55
Oyster Shell Lime	60 "	100	2½	40

Gas House Lime or Gas Lime:—Quick lime is used at the gas works for removing the impurities of the gas. After it has been saturated with the impurities, and no longer fit for use in gas making, it is sold for agricultural purposes under the name of gas-lime. This article varies considerably in composition, but consists essentially of the hydrate, carbonate, sulphate, sulphides and sulphites of lime. The sulphides and sulphites of lime are injurious to germinating seeds or young and tender plants, so that gas lime should be applied cautiously and when not too fresh. The action of the air on sulphides and sulphites changes them to sulphate of lime (gypsum or land-plaster); hence the exposure of gas-lime to the weather for some time improves its agricultural qualities. Average gas-lime contains about 22 per cent. water, 43 per cent. lime (CaO), 21 per cent. Sulphuric Acid (Oil of Vitriol), 8 per cent. Magnesia, and 6 per cent. insoluble matter. Of course this will vary considerably according to the character of the lime used, and the amount and nature of the impurities. The gas houses in Baltimore and Washington, D. C., use mostly oyster shell lime, and the gas lime from such lime would contain very much less Magnesia than indicated by the average figures. Gas-lime is usually sold at 65 pounds per bushel.

Gypsum or Land Plaster is a combination of lime with Sulphuric Acid (Oil of Vitriol) forming sulphate of lime. It occurs in nature in large deposits forming beds of rock. These are comparatively easily mined, and the rock is ground to a fine powder for commercial purposes. It varies in color from white or light yellow to gray. There are no natural deposits of gypsum in Maryland. Gypsum or sulphate of lime is formed artificially in the manufacture of phosphoric acid and phosphates, by treating the phosphates of lime with sulphuric acid, and a considerable amount of gypsum is necessarily used in agriculture in using dissolved bone and dissolved rock. Average gypsum contains about 32 per cent. Calcium Oxide (CaO).

Marl, is a name applied to earthy deposits containing more or less partially decomposed shells. These make the marl more or less friable or easily disintegrated by the weather. Marls are valuable as sources of lime, and, when they contain large amounts of lime, they are burned and thus furnish a source of quick-lime. Marls occur widely distributed in Maryland, and vary considerably in character and quality, as will be seen from the discussion and analyses in Table XXV.

Phosphates of Lime, are used extensively in agriculture, being furnished through the medium of bone, South Carolina, Florida and Tennessee phosphate rock, slag phosphates, and various guanos. These are really used for their phosphoric acid rather than for lime, and so are somewhat outside of the province of this bulletin.

Modes of Action of Lime.

In considering the question of the use of lime from a theoretical standpoint it would be very natural to conclude that lime is a necessary plant food. Lime is a substance that is just as essential to the plant as Nitrogen, Potash or Phosphoric Acid, and some of it must be present in the soil or no crop can grow. Nevertheless the requirements of the crop in this respect are very small, and but a few pounds of any lime compound per acre would suffice for any crop.

Lime is one of the most abundant substances. It has been estimated that not less than one-sixth of all the rocks on the surface of the earth are lime-stones, and that the element Calcium composes about one-sixteenth of the solid crust of the earth. From this it will be gathered that lime is sufficiently diffused in nature to supply the needs of most plants for this food. Indeed there are few arable soils so poor in lime as not to contain far more than would supply all the demands of crops for years; yet it may happen that in some sandy regions, and in soils that have resulted from the decomposition of certain substances, slates and other rocks poor in lime that there would be a deficiency of lime for serving as nourishment for plants; but in such cases the deficiency of other plant food would be more marked, and in supplying them from the sources ordinarily available the lime would be supplied in abundance for the food requirements of the crops.

The action of lime on soils may be considered under three heads: 1st—Chemical action, 2nd—Physical action, and 3rd—Supplying a plant food. It is only the first and second divisions that have much importance for the Maryland farmer. Lime is termed an indirect fertilizer in consequence of the little need of it as a plant food, and because of its benefits being derived from its chemical and physical action on the soil. Different kinds of lime have, in the main, much the same kind of action, but they differ in the degree and avidity of the inaction.

Chemical Action of Lime on Soils.

One of the most important chemical changes brought about in a soil through the action of lime is the decomposition of minerals, particularly the disintegration of refractory silicates. Such action as this would generally be produced more easily by caustic or quick-lime than by any other form. Lime materially aids in the formation of double silicates of alumina, which have an important influence on the fertility of the land. Double silicates of alumina may be described as silicates of alumina in which part of the alumina is replaced by lime, soda, potash or ammonia. Most farmers are aware that ammonia is more valuable than potash, whilst potash is more valuable than soda and soda is more valuable than lime The double silicates of alumina, when once formed seem to recognize this, and exercise a similar order of preference. If a double silicate of alumina and lime exist in the soil and should be brought in contact with soda, some of the lime will be given up and soda will replace it, resulting in a silicate of alumina and soda. The presence of the lime will not enable it to replace the soda, as the silicate of alumina prefers the soda to the lime. If, however, potash be added, the soda is given up and potash taken into the combination, because the silicate of alumina prefers the potash. But if ammonia comes within the influence of this compound it will replace either the lime, soda or potash, and silicate of alumina and ammonia would be formed. These double silicates are in such shape as to be lost from the soil by leaching, yet are in a readily available condition for plants. From this it will be seen that it is desirable to promote the formation of double silicates, and caustic lime seems to have a decided action upon clays in starting and bringing about the formation of this most desirable class of bodies.

Lime and Potash.—Lime has not only the effect of ading in the formation of unions of potash which will be held in the soil, but it also has the ability to liberate potash from combinations which are locked up and unavailable to plants. This is particularly marked when lime is applied to land containing fragments of feldspar. Gypsum is particularly useful in rendering potash available, and the sulphate of lime in dissolved phosphates often have an indirect value in this way.

Lime also favors the production of nitrate of potash in the soil. This is particularly true when lime is used on soils receiving considerable stable manure. The process and changes involved are exactly similar to those which have been employed in many places for the production of nitrate of potash (Nitre) for use in the manufacture of gunpowder, and for which a prize was awarded by the French Government to Mons. Thouvenel in 1776.

Lime and Organic Compounds.—Lime hastens the decomposition of organic matter and inert nitrogen compounds of humus in the soil, and promotes the formation of ammonia and nitrate compounds from the same. It also, as has been seen above, aids in the formation of compounds not easily removed from the soil. Lime promotes nitrifying ferments and makes possible their existence in many cases that would be impossible without its presence.

Lime produces particularly good results if applied after using green manures, as it acts chemically and unites with some parts of the organic matter and leaves the remainder in a disorganized condition which rapidly decomposes. It is, perhaps, this tendency to destroy organic matter that makes the frequent use of lime pernicious. All evidence teaches us that lime is no substitute for manure but only a reinforcement of it. No doubt much land has been reduced to the verge of sterility by applying lime continually until all the organic matter has been used up. Such procedure is probably responsible for the old proverb, "Lime enriches the father but beggars the son."

Lime and Phosphoric Acid.—If a soil contains much phosphoric acid combined with iron and alumina which is relatively inert, an application of lime will change it into a form available to plants. Lime applied to soils which have received or will receive applications of dissolved phosphates, will not produce any harmful results or cause a loss of the phosphoric acid. It may hasten the reversion of the soluble phosphoric acid, but the phosphoric acid will still be in an available condition. In the average soil this reversion takes place any way within twenty-four hours after applying the phosphate.

Lime Corrects Acidity.—Most cutivated soils possess a slightly acid reaction. This is generally due to decomposition of the remains of plants in the soil forming organic acids. On wet soils this condition is more noticeable than on dry soils. The sour humus and organic acids are not only unfavorable to the growth of nitrifying ferments and the root tubercles of leguminous plants but also are likely to dissolve iron and other compounds which are poisonous to microbes and crops. Water-culture experiments have shown that slightly acid solutions are favorable to the growth of plants, and while most soils possess this character to a slight degree, yet any excess of soluble acid in the soil would be highly detrimental. While most of our cultivated crops seem to need a slight acidity, it is probable that they have the ability to create this condition to a sufficient degree through the medium of the solutions sent out by their roots. This being the case, it would seem that the aim should be to keep soils in a neutral or slightly alkaline condition so as to favor the growth of root tubercles of the legumes and the desirable soil ferments.

Liming is excellent for correcting any excess of acidity, and is probably the most effective and economical substance for bringing about these other desirable conditions.

Physical Results of Liming Soils.

The many chemical changes brought about by the action of lime on soils result in producing physical changes which give soils new mechanical characteristics. Lime has the power of changing the physical properties of a clay soil and making it more friable and easily cultivated, and putting it in a condition so that water may pass more freely through it. This will make it less susceptible to extremes of dry or wet weather, and make it a good home for the roots of the plants. The action of lime on sandy soils may be said to be the reverse of that on clay soils; that is, it has a cementing action, making such soils stick together and in such a condition that they will hold more water and not dry out so rapidly.

The changes are brought about by what is termed the "flocculation" of the clay and organic particles. It has been found that one (1) part of lime has the power to flocculate and clear 10,000 parts of a turbid liquid, so that it can be readily understood that an application of one ton (35 bushels) of lime would have marked effect on an average soil to the depth of six inches which weighs approximately 900 tons.

Other Effects of Lime.

As has been stated, applications of lime produce a beneficial effect in giving a favorable medium for the growth of nitrifying organisms and of the root tubercles on the leguminous plants (particularly the clover). Lime is also sometimes applied to prevent the "Club-foot" of cabbage, celery and of certain root crops. It is sometimes used to destroy larvæ, slugs and worms, but experiments do not bear this out and it is doubtful if it has such an effect. Applications of lime are also supposed to favor the development of certain injurious and undesirable conditions such as the scab disease in potatoes.

EFFECTS OF LIME ON VARIOUS PLANTS.

The experiments conducted by the Rhode Island Experiment Station have resulted in the following classification of plants according to their action with reference to lime:

TABLE XVII

Giving approximate Effects of Lime on various Plants.

Plants Benefited by Lime.	Plants Indifferent to Lime.	Plants Injured by Lime.
Spinach,	*Corn,	Watermelon,
Lettuce,	Millet,	Serradella,
Beets,	Hungarian Millet,	Blue Lupine,
Okra.	Golden,	Sheep Sorrel.
Salsify,	Rye.	
Celery,	Potatoes,	
Onions.	Carrots,	
Parsnips,	R. I. Bent Grass,	
Cauliflower,	Red top Grass.	
Cabbage,		
Cucumbers,		
Egg Plants,		
Cantaloupes,		
Asparagus,		
Kohl-rabi,		
Dandelion,		
Swedish Turnip,		
Pepper,		
Pea,		
Peanuts,		
Tobacco,		
Sorghum,		
Alfalfa,		
Clover,		
Barley,		
Wheat,		
Oats,		
Timothy,		
Ky. Blue Grass,		
Seed Fruits,		
Stone Fruits.		

*Experiments at this Station have shown applications of lime to corn to give marked increase in yield.

From the list it will be seen that most all of the crops commonly grown in Maryland, are benefited by application of lime.

TIME OF THE YEAR TO APPLY LIME.

The fall is generally considered the best time to apply lime, but moderate application may be made whenever the farmer finds it convenient to perform the work. With the conditions generally prevailing in this State it will usually be found most convenient to haul the lime in the winter and apply it in the spring in order to get it harrowed into the land. Much of the fall grain is seeded on corn ground and this land is not plowed up or in shape to apply the lime advantageously at that season.

It will be noted that most of the experiments reported in this bulletin are with spring applications.

How Much and How Often to Apply the Lime.

The quantity of lime applied varies considerably in the various sections and at various times. This has probably been due in a large measure to the cost of lime and the relative distance it must be hauled. Recent observations seem to indicate that it is better to apply small quantities and make the applications at frequent intervals rather than apply very large quantities at one time. The old practice of putting 100 bushels or more per acre is seldom practiced now. The kind of soil to which the application is made makes it necessary to vary the quantity. It is now pretty well recognized that on poor soils and on sandy soils, the quantity applied at one time should be small. The quantity and frequency are points that are under test at this Station. See the results in Tables II to VII, pages 2 to 9.

Method of Applying Lime.

There is probably considerable energy wasted and money lost in the manner in which lime is applied.

In the first place it should be remembered that the tendency of lime is downward in the soil, so it should always be applied at the surface and never plowed under. In the second place it should be remembered that the lime, when in its caustic or quick state, has the most power in producing chemical and physical changes in the soil. For this reason the aim should be to get the lime into the soil in its active state, and have it thoroughly incorporated in the soil before it has had a chance to lose any of its active principles. See results on another page. With this idea in mind, lime should be slaked by means of water, and, as soon as in a powdery state, be spread over the land and at once harrowed in, to thoroughly incorporate it in the soil, lime should not be allowed to "*air*" slake, as by so doing it absorbs considerable carbonic acid from the air and some of it is changed back to the carbonate, the chemical form in which it existed before burning and consequently some of that which was paid for in burning is lost. Lime put on small or large piles to slake should be covered with earth to keep it out of contact with the air while slaking, and, as soon as it has come to a powdery condition, it should be spread on the land and harhowed in.

It will generally be found more economical to haul water to apply to the lime and slake it at once rather than cover with earth.

Slaking with water would be a more economical method than to lose part of the value of the lime through air slaking.

When it can be avoided do not apply lime on top of the land with the idea that the rains will dissolve it and carry it into the soil, for, in the first place the rains may not come until after some lapse of time and much of the lime will have returned to the carbonate; and, in the second place, it takes 700 pounds of water to dissolve one pound of lime and that amount of rain could not be depended upon.

Recently lime has been put on the market in a powdered caustic state so that it can be applied to the land with a grain drill or lime-spreader or by most manure spreaders and get it thoroughly incorporated with the soil while it is still in the quick state which, theoretically, should be the best way. This kind of lime also affords an opportunity to apply small quantities and get it more evenly distributed than is possible with a shovel.

The lime spreaders or the lime attachments which come with most manure spreaders will be found very valuable for spreading slaked lime and particularly so when only small quantities per acre are to be used.

The system of putting lime in small (one bushel and one-half bushel) piles all over the field and allowing it to slake before spreading is not to be recommended, as it usually will be found not to be the easiest and most economical means of application; but in case this method of doing the work is desired the following table of distances may be found helpful to many.

TABLE XVIII.

Showing distances apart that 1 *bushel and* ½ *bushel piles of Lime should be placed to cover an Acre with a given quantity.*

Bushels per Acre.	One Bushel Piles	One-half Bushel Piles
	Number of Feet Square.	
20	46½	33
25	41¾	29½
30	38	27
40	33	23¼
50	29½	20¾
60	27	19
70	25	17¾
75	24¼	7
80	23½	16½
90	22	15½
100	20¾	14¾
		1

When lime is applied in this way care should be taken to never allow it to lay until it becomes mucked or to spread it when it is wet.

How to Determine the Need for Lime.

There have been numerous methods proposed for determining the need for lime and the probable quantity required; none of them are very reliable and all take more or less skill in their application. The most reliable test is evidenced by the crop, but this takes considerable time. Probably the easiest test is the use of blue litmus paper for testing the acidity of soils, and if it turns red rapidly it will generally indicate the need for lime. The blue litmus paper test is very simple; it is made by bringing a piece of blue litmus paper in contact with the moistened soil and observing the intensity and rapidity of the redness thus produced.

The general characteristics of the land as to its derivation can not be taken as a sure indication of the lack or supply of lime. It is not infrequent to find that in lime-stone regions and on the so-called lime-stone soils that applications of lime produce most marked results. This is due to the fact that the lime of lime-stone soils has been removed in a great part through prolonged decay and the dissolving action of the carbonated waters. This, not infrequently, leaves such soils so siliceous or ferrugenous as to be quite barren, and of a nature to be benefited by an application of lime. Throughout the areas occupied by the Trenton Lime-stones in Maryland, nearly every farm has, in years past, had its quarry and lime-kiln for fitting and supplying lime once more to soils that had been so thoroughly leached as to render them lean and poor.

The Occurrence and Composition of the Sources of Lime in Maryland.

Maryland is well supplied with lime for agricultural purposes. It is not only abundant, but quite generally and widely distributed.

The source of lime in Maryland may be divided into three general classes: first, lime-stone: second, marls: third, shells. The lime-stones occur widely distributed throughout the western part of the State, and the marls throughout the tide-water areas of Southern Maryland and the Eastern Shore. The shell, derived mostly from the oyster. is burned into lime and used more or less in all parts of the State, but most generally in the tidewater sections.

In studying the sources of lime available in this State eighty-six samples, representing the various deposits, were furnished to us by Dr. Wm. B. Clark, State Geologist, which were duplicates of those procured in making the geological survey. These samples were analized and the results are found in Table XIX.

In addition to the report on the analyses of the samples furnished by the Survey, will be given the analyses of those that have come to this Station from time to time during the past eighteen years, together with a compilation of a few of the analyses of the Maryland limes and lime-stones which have come to our attention. These samples, in some instances, have been sent by the manufacturers and in others by the users of the lime, hence the Station can only report on the quality of the sample received, and can, in no degree, vouch for the authenticity of the sample.

By referring to the analyses as given in the tables, it will be seen that limestone of good quality for agricultural purposes occurs quite widely and generally distributed in Maryland, which, together with the marls and abundance of oyster shells in the bay and tide water sections, puts lime within easy reach for all. The variation in the quality of lime-stones in this State makes it possible to procure any grade desired, and where special advantages are obtained on some soils through the use of pure lime, magnesium lime or alum lime, they can be taken advantage of, and all at about the same cost. A study of the quality of these various deposits makes it evident that where the simple effect of the lime is desired, that it could be obtained by using some of the local sources of lime and thus save much that is now being paid for freight in transporting lime from a relatively distant quarry.

There are few states where the farmers are so fortunate as to have some source of lime at almost every door, and there is no doubt but that it could be used advantageously by many, if applied judiciously, who are not now availing of this means of improving the fertility of their lands.

TABLE XIX.

Description and Composition of Samples of Limestone furnished by the Maryland Geological Survey.

T. MALCOLM PRICE, *Analyst.*

(Figures indicate per cents, or pounds in 100 pounds.)

Laboratory No.	Survey No.	Geological Classification.	Locality.	Insoluble matter, sand, silica, etc.	Iron and Aluminium Oxides.	Calcium (lime) Carbonate ($CaCO_3$)	Magnesium Carbonate ($MgCO_3$)	Total.
2140	8	Archean	Carroll county......................	0.43	9.00	89.99	1.02	100.14
2141	4077	Cambrian	Scaggs Quarry, 1 mile west of Highlands, Howard county............	48.39	14.24	35.66	1.96	100.25
2142	4078	"	Wm. Federline's lime kiln, 1½ miles west of Highlands, Howard county	10.13	10.94	75.67	3.70	100.34
2143	4642	Carboniferous	West of George's Creek, on the north side of Carlos Branch Railroad, 3 miles south of Frostburg, Allegany county..................	3.89	12.16	83.57	1.87	99.89
2144	4683	"	West of Lonaconing, near the Allegany-Garrett county line, 105 feet above the "Gib vein" Coal Mine, near the "Old Spring" at the new furnace shaft south of Koonts run.	4.37	19.62	74.70	2.01	98.69
2145	4685	"	Mouth of Stony Run, on the Potomac, 2 miles east of Western Port, Allegany county..................	3.65	8.44	85.87	1.30	99.26
2146	4	"	Gerrenger & Sugarhart's Quarry, near Friendsville, Garrett county.	13.65	5.44	79.16	1.21	99.46

2147	4698	"	On the west side of George's Creek & Cumberland Railroad; ½ mile west of Vale Summit, in bed of ravine. Allegany county.........	1.44	6.94	90.40	0.99	99.79
2148	4641	"	From old opening on roadside; 1 mile north of Frostburg, near N. Y. Mine opening, Allegany county..	25.01	48.92	7.83	18.70	100.46
2149	3	"	Offut's Quarry, 5 miles south west of Oakland, Garrett county......	13.46	12.48	72.92	1.15	99.91
2150	4693	"	Mouth of Stony Run on the Potomac. 2 miles east of Western Port, Allegany county.....................	11.52	3.37	74.48	10.99	100.36
2151	4676	"	In east bank of George's Creek, in town of Barton, Allegany county, only a few inches thick...........	20.22	25.54	51.10	3.40	100.26
2152	4643	"	Top stratum of lime-stone in C. & P. R. R. cut; just south of crossing, near pumping shaft; 3 miles south of Frostburg, Allegany county...	10.63	13.18	73.73	1.61	99.15
2153	4715	"	On Potomac Gravity Plain. 1½ miles east of Barton; about 80 feet above bottom of Fairfax formation, Allegany county............	9.86	4.90	83.69	1.96	100.41
2154	4709	"	Near top of Fairfax formation; on W. S. Trimble's farm, south-east Mt. Savage Station, Allegany county..	22.03	51.16	24.80	1.88	99.87
2155	2	"	Lime kiln at Crabtree Station on B. & O. R. R. near Frankville, Garrett co.	8.57	2.38	88.73	0.86	100.54
2156	4667	"	Mouth of Stony Run, on the Potomac. 2 miles east of Western Port, Allegany county.....................	5.11	3.56	89.08	3.17	99.92

TABLE XIX—*Continued.*

Laboratory No.	Survey No.	Geological Classification.	Locality.	Insoluble matter. sand, silica, etc.	Iron and Aluminium Oxides.	Calcium (lime) Carbonate ($CaCO_3$)	Magnesium Carbonate ($MgCO_3$)	Total.
2157	4928	Chert Beds	North Branch, Allegany county.....	53.37	6.24	37.74	2.87	100.22
2158	7	Cockeysville Marble	Cockeysville, Baltimore county	9.79	5.62	70.64	14.61	100.60
2159	4629	Devonian	30 yards east of church on William's Road; about two miles east of Cumberland; 40 feet above the Romney-Monterey Contact................	30.37	61.62	5.19	2.80	99.98
2160	4639	"	On county road, near spring on fork of road near south end of Warrior Mountain, west of Oldtown, Allegany county.....................	89.80	2.16	7.14	1.07	100.17
2161	4723	"	West side of W. Va. Cent. R. R., in cut 20 yards north of Bridge across the Potomac. About 1 mile north of Keyser, W. Va. but in Allegany Co.	21.78	4.30	69.08	3.81	98.97
2162	3036	Greenbriar	Barrelville, Washington county.....	5.24	1.98	84.58	7.49	99.29
2163	35	"	South of Negro Mountain, Garrett Co.	20.95	41.10	37.35	0.91	100.36
2164	4103	"	Offut's Quarry; 6 miles north of Oakland, Garrett county..........	17.00	2.74	62.12	15.75	99.61
2165	8000	"	Findley's Quarry, Piney Run, Garrett county................	4.47	2.70	93.09	6.38	100.28
2166	3057	Lewistown	Cumberland, Allegany county......	3.51	3.30	90.48	2.37	99.60

2167	3055	"	Miller's Quarry, Allegany county...	1.83	2.40	92.96	2.83	100.02
2168	3059	"	Mrs. M. Rowan....................	3.47	2.64	88.85	4.36	99.32
2169	3058	"	C. F. Thrasher....................	3.75	2.58	82.41	11.01	99.75
2170	4110	"	Hancock, Washington county.......	5.97	12.94	79.42	1.13	99.46
2171	9	"	Pinto, Allegany county............	20.90	33.14	36.96	8.62	99.62
2172	10	"	" " "	17.91	6.14	73.13	2.48	99.66
2173	11	"	" " "	34.01	5.60	59.03	1.81	100.45
2174	3	"	Clement vein No. 3 Clement Works, Pinto, Allegany county...........	26.43	8.18	52.35	12.81	99.79
2175	4	"	Near top layer at Rawlins kiln, Potomac, W. Va....................	1.20	3.60	90.69	4.69	100.18
2176	4154	"	Flintstone, Allegany county	5.57	4.43	84.32	5.93	100.25
2177	4914	"	Cut in B. & O. R. R. at Clement Mill, Pinto, Allegany county......	14.50	4.40	79.41	1.02	99.33
2178	5	"	Potomac Station, Allegany county..	16.33	14.48	62.64	6.17	99.52
2179	2	Monterey	Limey layers near top of Oriskay S. S., Cumberland, Allegany county.	57.49	4.40	26.88	10.79	99.56
2180	7095	Newark	Lime stone *breccia*, Tyson's Quarry, Mt. Pleasant, Frederick county...	5.75	8.74	76.78	9.15	100.42
2181	4645	Permian	On east side of Cumberland & Pa. R. R.; about 250 yards north of Frostburg, Allegany county............	32.41	11.32	53.42	2.33	99.48
2182	4139	Shenando'h	Cavetown, Washington county......	12.00	4.42	83.10	0.93	100.45

TABLE XIX—*Continued.*

Laboratory No.	Survey No.	Geological Classification.	Locality.	Insoluble matter, sand, silica, etc.	Iron and Aluminium Oxides.	Calcium (Lime) Carbonate ($CaCO_3$)	Magnesium Carbonate ($MgCO_3$)	Total.
2183	4151	Shenandoah	Sharpsburg, Washington county....	0.70	2.84	91.32	5.05	99.91
2184	6	"	Leitersburg, Washington county....	3.53	3.42	90.01	2.13	99.69
2185	3056	"	Leopold's Quarry..................	1.51	5.90	89.07	3.25	99.73
2186	4145	"	North edge of Flintstone, Washington county........................	21.84	12.08	64.33	1.76	100.01
2187	1	"	Keedysville, Washington county....	0.63	6.30	90.92	2.49	100.34
2189	4150	"	On C. & O. Cent. Canal, 4 miles south of Sharpsburg, Washington county	2.14	6.70	89.82	1.10	99.76
2188	4127	"	Southeast of Leitersburg on road near creek........................	4.17	8.04	81.73	6.62	99.56
2190	4141	"	Cavetown, Washington county......	20.32	8.60	66.80	3.36	99.08
2191	7006	"	Cramer's Quarry, Mt. Pleasant, Frederick county.................	11.13	8.00	78.62	2.60	100.05
2192	7115	"	Mountview, Frederick county.......	4.99	6.28	84.14	3.97	99.38
2193	7104	"	C. J. Keller's Quarry, Buckstown, Frederick county.................	33.36	6.65	57.41	3.02	100.39
2194	7070	"	Union Bridge, Carroll county.......	0.56	1.50	97.14	0.81	100.01
2195	7071	"	" " "	0.50	2.94	95.44	1.33	100.21

2196	7073	"	" " "	0.43	4.28	94.10	1.64	100.45
2197	7102	"	Frederick City, Frederick county...	1.65	3.26	90.23	5.19	100.33
2198	7021	"	H. Cramer's Quarry, Mt. Pleasant, Frederick county................	9.06	10.92	78.56	2.07	100.61
2199	7108	"	D. Roddy's Quarry, Thurmont, Frederick county.....................	0.52	4.54	92.67	1.80	99.53
2200	7106	"	D. Roddy's Quarry, Thurmont, Frederick county.....................	5.66	0.74	93.05	1.84	101.29
2201	7102	"	Mountview, Frederick, Frederick co.	4.64	0.14	93.14	1.39	99.31
2202	4199	"	Yost's Quarry, west of Hagerstown, Washington county..............	4.99	0.44	91.03	3.28	99.74
2203	4180	"	Deitrich Quarry, west of Hagerstown, Washington county.........	9.46	4.04	62.10	4.63	99.37
2224	7098	"	Barrett's Quarry, Woodboro, Frederick county.....................	2.33	10.10	81.57	5.60	99.60
2225	3056	"	Leopold's Lime Kiln. This is a duplicate in number and description to No. 2185, but different in appearance	1.93	5.66	83.35	8.50	99.44
2204	4175	Upper Silurian	A small lime kiln on National road, 4 miles northeast of Cumberland, Allegany county.................	0.75	0.16	92.19	7.38	100.38
2205	4618	Top of Silurian	Near the canal at south end of Nicholas mountain, at the Louistown-Monterey contact, Allegany co....	10.68	6.98	79.89	2.82	100.35
2206	4125	Silurian	Murray lime kiln, 2½ miles west of Hancock, near the National road.	12.38	3.30	83.59	0.69	99.97

TABLE XIX—*Continued.*

Laboratory No.	Survey No.	Geological Classification.	Locality.	Insoluble matter, sand, silica, etc.	Iron and Aluminium Oxides.	Calcium (lime) Carbonate ($CaCO_3$)	Magnesium Carbonate ($MgCO_3$)	Total.
2207	4153	Silurian	Western Maryland Railroad Quarry; 2½ miles west of Williamsport, Washington county	4.04	9.80	77.10	8.38	99.22
2208	4128	"	On roadside near Leitersburg, Washington county	5.42	4.20	89.61	0.07	99.30
2209	4143	"	North suburbs of Funkstown, Washington county	0.62	8.08	85.82	5.88	100.40
2210	4131	"	Roadside near Leitersburg, Washington county	4.08	4.70	82.03	9.71	100.52
2211	4111	"	At side of National Road, in western suburbs of Hancock, Washington county	3.80	4.00	89.53	2.42	99.75
2212	4155	"	Yost's Quarry, about 5 miles west-northwest of Hagerstown, Washington county	0.80	4.64	92.19	2.84	100.47
2213	4504	"	From out crop on National Road in eastern suburbs of Flintstone, Allegany county	1.88	5.98	89.64	2.42	99.72
2214	4148	"	Near C. & O. Canal; 4 miles south of Sharpsburg, Washington county	1.79	3.46	83.33	11.50	100.08
2215	4177	"	Byer's Quarry, in northern suburbs of Hagerstown, Washington county	3.65	4.44	91.92	0.25	100.08

2216	4179	"	Yost's Quarry, (?) miles west of Hagerstown....................	2.39	1.47	92.74	2.57	99.17
2217	1	"	Mullen's lime kiln, in northeast part of Cumberland, Allegany county..	12.27	12.88	73.46	0.86	99.47
2218	4154	"	So-called "Black Marble," 1½ miles south of Flintstone, Allegany Co..	5.92	12 98	79.92	0.36	99.18
2219	4500	"	East side of Flintstone Creek, ¼ mile north of Flintstone, Allegany Co..	7.33	9.18	83.60	0.22	100 33
2220	4152	"	Railroad cut, 2 miles north of Keedysville, Washington county..	3.21	4.12	91.85	0.74	99.92
2221	4180	"	Dietrick's Quarry, (?) miles west of Hagerstown, Washington county..	11.00	8.20	77.51	3.25	99 96
2222	4140	"	Limestone Quarry in Cavetown, Washington county..........	0 74	6.98	91.01	0.74	99.47
2223	3065	Spencer	Pinto, Allegany county............	0.79	9.03	87.03	2.60	99.35

TABLE XX.

Description and Composition of Miscellaneous samples of Limestone sent to the Experiment Station for Analysis.

H. J. PATTERSON, Analyst.

(Figures indicate per cents, or pounds in 100 pounds.)

Laboratory No.	Description of Sample.	Sent by:	Insoluble matter, sand, silica, etc.	Iron and Aluminium Oxide.	Calcium (lime) Carbonate, ($CaCO_3$)	Magnesium Carbonate, ($MgCO_3$)	Undetermined.	Total.
802	Gray Limestone, Lime Kiln, Maryland	M. J. Grove Co., Lime Kiln, Maryland	0.31	0.14	93.49	5.95	....	99.99
803	Blue Limestone	M. J. Grove Lime Co., Lime Kiln, Maryland	3.90	0.36	93 26	2.50	....	100.02
1042	Pulverized Marble	Beaver Dam Marble Co., Cockeysville, Maryland	2.33	1.55	52.33	43.69	0.08*	99.98
1542	Limestone	E. H. Brown, Johnsville, Md.	7.15	11.90	51.61	27.45	1.89†	100.00
1563	Micaceous Gray Limestone	Mrs. Hopkins, Highlands, Md.	13.60	5.15	77.82	3.19	0.24†	100.00
1565	Limestone	E. W. Adams, Clarksville, Md.	13.00	6.00	50.00	31.00	....	100.00
1567	Limestone	T. T. Hershberger, Frederick, Md.	10.17	5.53	78 12	6.18	....	100.00
1879	Mixture of blue, dark-gray and light-gray stone	J. W. LeGore, Woodsboro, Maryland	0.50	0.60	98.39	0.51	....	100.00
1991	Gray Limestone	Aaron Wood, Woodsboro, Md.	5.30	9.80	53.57	31.33	....	100.00
2116	Limestone	J. N. Clery, Frederick, Md.	6240	7.60	30.00	6.00	....	100.00
2122	Lightest-gray Limestone	J. W. Stimmel, Walkersville, Md.	4.73	1 40	93.51	0.30	0.06	100.00
2123	Gray Limestone	J. W. Stimmel, Walkersville, Md.	4.31	0 90	81.79	13.00	....	100.00
2127	White Limestone	Kerr Bros. Co., Wrightsville, Pa.	0.49	1.80	94.53	3.18	....	100.00

2128	Gray Limestone	Kerr Bros. Co., Wrightsville, Pa.	0.26	3.10	93.32	3.32	....	100.00
2226	Gray Limestone	Joshua C. Miller, Boonsboro, Md.	1.26	10.63	88.07	0.00	0.07	100.00
2227	White Limestone	Joshua C. Miller, Boonsboro, Md.	1.95	9.92	83.39	3.19	0.55	100.00
46	Oyster Shells	Sample analyzed by J. R. Laughlin	1.15	1.00	94.75	0.00	2.44†	......
47	" "	" " "	1.12	1.31	92.94	0.00	3.79†	......
	Blue Limestone	James W. Smith, Walkersville	0.89	0.50	98.00	0.66	....	100.05
	Red Limestone	James W. Smith, Walkersville	1.44	3.60	64.70	30.49	....	100.23
2299	Jamaica Limestone	A. R. Mitchell, Hereford	0.45	4.76	71.10	23.89	....	100.20
2517	Marble	B. Gardenhouse, Smithsburg	1.16	2.44	92.03	4.72	....	100.35
2518	White Limestone	L. J. Kemp, Woodstock	2.54	0.76	96.07	Trace	....	99.37
2519	Gray Limestone	L. S. Kemp, Woodstock	5.56	5.14	76.60	13.05	....	100.35
2656	Blue Stone	J. S. Norris, Md. & P. R. R.	0.60	19.78	49.80	29.74	....	99.92
2766	Limestone No. 1	E. R. Allen, Union Bridge	1.16	0.86	88.92	8.05	1.01	100.00
2767	Limestone No. 2	E. R. Allen, Union Bridge	0.16	1.25	60.81	36.51	1.27	100.00
2768	Limestone No. 3	E. R. Allen, Union Bridge	0.98	0.49	94.52	4.21	....	100.20
2788	Blue and Gray Limestone	C. A. Rogers, Buckeystown	0.17	0.26	98.16	0.69	....	99.28
2816	Limestone	J. S. Norris, Md. & Pa. R. R.	6.94	1.04	87.52	4.50	....	100.00
2860	Limestone	M. J. Grove, Lime Kiln	0.85	0.72	58.73	38.92	....	99.22
2880	Limestone	J. W. Carder, Oldtown	8.55	2.30	47.16	41.38	....	99.39
2881	Limestone	J. W. Carder, Oldtown	4.47	0.20	73.90	2.74	8.69	100.00

*Water in the marble dust. ‡Potash calculated as K_2O.

†Water—These samples had 0.10 and 0.24 per cent. phosphoric acid, respectively.

TABLE XXI.

Composition of miscellaneous samples of Maryland Limestone.

(Analyses procured from various sources).

(Figures indicate per cents., or pounds in 100 pounds.)

Description of Sample.	Analyst.	Insoluble matter, sand, silica, etc.	Iron and Aluminium Oxides.	Calcium (lime) Carbonate, ($CaCO_3$)	Magnesium Carbonate, ($MgCO_3$)	Undetermined.	Total.
Cockeysville Marble	Schneider	5.57	0.40	51.90	42.60	.....	100.47
Cockeysville Marble	Whitefield	0.44	Trace	54.87	43.84	.....	99.15
Cockeysville Marble	Higgins	2.33	0.00	52.33	43.70	.....	98.36
Texas Limestone	Williams	2.00	0.00	93.00	5.00	.....	100.00
Washington Co. Limestone, from Dr. T. Maddox	Dr. Higgins	5.80	0.10	90.70	3.18	0.12	......
" " " "	"	0.60	0.00	98.53	0.87	0.00	......
" " " David Zellers	"	0.25	.....	96.75	2.75	0.25	......
" " " B. J. Beyers	"	2.40	0.60	94.76	2.25	Trace	......
" " " I. E. Davis	"	3.00	0.27	53.94	42.79	Trace	......
" " " "	"	0.70	0.00	54.93	44.35	Trace	......
" " " George Heyser	"	2.00	0.30	95.00	2.60	0.10	......
" " " John T. Mason	"	2.00	0.64	56.50	30.80	0.00	......

Washington Co. Limestone, from James Biays.....	“ ..	0.60	0.00	98.53	0 87	0 00	......
Specimen from head of Pleasant Valley...........	“ ..	6.00	0.20	90 70	3.00	0 00	......
“ “ Beaver Creek............	“ ..	0.20	0 10	97.00	2.50	0 30	......
“ “ near Williamsport.........	“ ..	0 50	0.10	98 50	0.80	0 10	.....
“ “ Carroll county:							
White limestone from Unionville.................	“ ..	0.50	.....	99.50	0 00	.....	......
Dark gray Limestone from Rinehart	“ ..	20 20	.....	68.30	11 50	.....	......
Dark gray Limestone with white veins.......	“ ..	0 70	.....	98 80	0.50	.....	......

TABLE XXII.

Description and Composition of Miscellaneous Samples of Burned (Quick) Lime, sent to the Experiment Station for Analysis.

H. J. PATTERSON, Analyst.

(Figures indicate per cents, or pounds in 100 pounds.)

Laboratory No.	Description of Sample.	Sent by:	Insoluble matter.	Iron and Aluminium Oxides.	Lime (CaO)	Magnesia (MgO)	Undetermined.*	Total.
1043	Woodsboro Lime.........	W. H. Biggs & Bro., Rocky Ridge, Md..............................	1.85	3.10	91.10	0.92	3.03	100.00
1044	Cavetown Lime	W. H. Biggs & Bro., Rocky Ridge, Md..........................	2.75	4.83	73.90	17.94	0.58	100.00
1543		Adam Diehl, Jr., Walkersville, Md.	1.35	0.75	83.40	0.72	13.78	100.00
1723	Oyster Shell Lime.......	Purchased in Baltimore City........	.....	.....	61.75	.....	.....	......
1724	Stone Lime.............	“ “ Silver Spring, Md.....	.....	.....	95.25	.....	.....	......
1725	Gas House Lime.........	“ “ Baltimore City........	.....	.....	42.50	.....	.....	......
1732	Wrightsville Lime.......	Edward Boynton, Port Deposit, Md.	0.15	1.50	67.44	30.91	.....	100.00
1790	Grove's Lime..........	P. C. Prough, Freedom, Md........	25.00	2.40	47.10	25.16	0.34	100.00
1791	Black's Lime............	“ “ “	19.71	7.00	69.80	2.02	1.47	100.00
1848	LeGore's Combination Lime..................	W. O. Thomas, Sudlersville, Md....	1.63	1.20	96.00	1.08	.....	100.00

1949	Frederick City Lime Co's Lime................	Frederick City Lime Co., Frederick, Md..............................	7.70	2.55	84.89	4.86	.....	100.00
2019	Aaron Wood's Lime.....	Aaron Wood, Woodsboro, Md.......	1.06	2.40	90.00	1.00	4.54	100.00
2130		Benjamin F. Rash, Worton, Md....	6.69	9.30	82.92	0.40	1.61	100.00
	Ground Stone Lime......	Maryland Agri. Experiment Station	2.60	8.26	82.06	2.94	3.14	100.00
	Glasshouse Lime.........	" " " "	6.33	9.56	83.11	0.35	0.65	100.00
	Howard County Lime....	Dr. Tatum, Ashton, Md............	6.02	13.30	75.40	2.00	3.28	100.00
2729	Wood-burnt Lime	B. D. Biggs, Thurmont.............	24.51	17.90	50.40	6.75	0.44	100.00

*Mostly water and carbonic acid gas.

TABLE XXIII.

Description and Composition of Samples of Quick Lime.

SAMPLED AND ANALYZED BY DR. H. B. MCDONNELL AND F. P. VEITCH.

(Figures indicate per cents, or pounds in 100 pounds.)

Laboratory No.	Description of Sample.	Sample taken at	Insoluble matter, sand, silica, etc.	Iron and Aluminium Oxides.	Lime (CaO)	Magnesia (MgO)	Water and Carbon-dioxide.	Total.
1	Gas Lime, fresh..........	Canton, Baltimore county, Md...	8.54	2.15	42.44	0.34	44.91	100.00
2	" " Weathered 1 year	" " " " ..	4.54	1.11	34.81	0.24	57.93	100.00
3	" " fresh..........	" " " " ..	4.41	1.47	37.50	0.29	55.41	100.00
4	" " "	Bayard Street, Baltimore, Md...	8.20	1.66	41.60	0.33	46.89	100.00
5	" " Weathered 10 yrs.	" " " " ..	8.70	1.65	30.83	0.20	57.70	100.00
6	Oyster Shell Lime, slaked fresh..................	" " " " ..	8.99	1.84	54.62	0.43	33.27	100.00
7	Oyster Shell Lime, fresh burned................	H. C. Pearson Packing Co., Baltimore, Md....................	5.79	2.71	84.58	0.55	5.92	100.49
8	Stone Lime from Texas, Md....................	Texas Lime Co., Baltimore, Md.	3.32	1.09	86.17	5.82	3.42	100.00
9	Stone Lime Crucible burned, select..........	Sent by the Standard Lime Co., from Engles, W. Va...........	0.22	0.44	98.06	0.50	0.67	100.00
10	Stone Lime from Frederick	Washington Grove,...............	18.96	3.14	69.18	15.77	2.95	100.00

11	Stone Lime from Lime Kiln	Boyds, Maryland	11.65	2.80	62.34	19.69	3.52	100.00
12	" " " Buckeystown	Mt. Airy, Woodbine and Derwood, Md	12.08	2.95	74.48	9.70	1.27	100.45
13	Stone Lime from LeGore.	Legore	6.27	1.86	87.09	4.39	0.81	100.42
14	" " " Martinsburg, W. Va*	Rockville and Sykesville, Md	1.72	1.93	93.49	0.73	2.13	100.00
15	Stone Lime from Engles, W. Va*	Rockville and Germantown, Md.	12.71	2.20	67.16	16.83	2.13	101.03
16	Stone Lime from Buckeystown, Md	College Park, Md	1.69	0.74	77.16	1.19	19.22	100.00

*Composite samples.

NOTE:—The gaslime contained, in addition to the above, small amounts of sulphur, sulphuric acid, and phosphoric acid; and the oyster-shell lime small amounts of phosphoric acid. These have been added in to make the total.

Maryland Marls.

Marls are found in large quantities in many parts of Maryland; and have been used more or less for agricultural purposes for many years. From the small quantity of plant food which marls furnish, and the difficulty and expense of handling and transportation, their use is generally confined to places very near the deposits.

Marls may be considered in three classes, according to their general character and the geological formations in which they occur, being only three of the many formations in this State. These formations are found, as a rule, one above the other, but it is rare that more than one occurs in a single exposure. The upper marl known as shell marl or blue marl, is found in the Neocene or the most recent of these formations, at very near the surface. It consists chiefly of seamud, with sand and clay and partially decayed shells and bones. Its value depends mainly on lime, which it contains in the form of the carbonate. This class of marls usually has a very small per cent. of phosphoric acid and potash, although sometimes it contains beds of glauconite which gives a higher potash value. The physical character of these calcareous marls varies with the class of animal remains from which they are derived, and the state of preservation of the same. To this class belong most of the marls that have been examined at this Station, as this Neocene formation covers a large area in Southern Maryland.

The second class of marls is found in the Eocene formation, which is older than the Neocene and is just below it in the geological order. It is friable and somewhat chalky, consisting of comminuted shells and corals, and is of a light color. The agricultural value of this variety is given by the potash and the carbonate of lime which it furnishes. The glauconite or green sand may be expected to be found in this class. In parts of New Jersey this is very prominent, but the per centage of potash has been found, as a rule, to be much lower in this State.

The third class, or that which has the lowest geological position is the cretaceous marl. This also contains glauconite and is commonly known in New Jersey as "green sand." There are very few exposures of this formation in Maryland and it is difficult to distinguish it from the Eocene. Marls of this class vary considerably in their chemical composition and agricultural value. They owe their fertilizing quality to the presence of phosphoric acid and potash, and sometimes contain a goodly admixture of calcareous matter. The best New Jersey marls, and those that have been used with the most success, have contained from two to three per cent. of phosphoric acid and from five to seven per cent. of potash. The few Maryland marls of this class that have been examined thus far have not given nearly as high a per cent. of these ingredients.

Marls occur in each of these three geological formations in a succession of beds varying in thickness from a few inches to many feet, and separated by layers of gravel, sand or clay. There may be many of these beds of marl in the same formation, and several beds of the same class are often seen in the same exposure, but the different classes of marl are rarely seen together.

The potash of marls, being in an insoluble form, must necessarily act very slowly in the soil. Much of the potash in marls will become slowly available to plants through weathering, but a considerable amount of it could be rendered available by the action of lime, which probably takes place through the formation of the double silicates spoken of on page 95. This change could readily be brought about by burning those marls which contain considerable Calcium (lime) Carbonate, and then slacking the product. This could be performed with profit with some of the marl deposits of the State and give a cheap source of lime, at the same time furnishing some potash and phosphoric acid. Such applications would be highly beneficial to the lands on the farms in the neighborhood of such deposits.

The following table gives the results of the examination of ninety-five separate samples from various parts of this State. Collectively, the samples reported upon in this table XXV are believed to represent in character and composition, all the deposits in Maryland, which are so exposed as to be accessible for use.

TABLE XXV.

Description and Composition of Marls sent to the Experiment Station for Analysis.

H. J. PATTERSON, Analyst.

(Figures indicate per cents, or pounds in 100 pounds.)

Laboratory No.	Description and source of sample.		Insoluble matter.	Lime (CaO)	Phosphoric acid P_2O_5	Potash K_2O
35	Upper layer 7 feet thick.	Sent by H. M. Murray, West River..........	68.50	0.38	0.58	3.22
36	Under No. 35, 5 feet thick.	“ “ “ “ “	63.77	0.25	0.32	3.02
37	Under No. 36, 40 feet thick.	“ “ “ “ “	68.45	0.25	0.34	3.52
38	Deposit near Stream.	“ Richard Baldwin, Waterbury.........	89.02	....	0.08	0.25
42	Sand and shell marl.	“ Spear and Critcher, Glymont.........	46.12	31.92	0.14	0.49
43	“ “ “	“ “ “ “	62.71	17.22	0.05	0.59
49	Lime marl.	“ Fred. Sasscer, Upper Marlboro.......	70.76	0.23	0.58	2.37
50	Shell marl.	“ “ “ “ “	60.51	14.71	0.12	1.89
51	Sand marl.	“ L. B. Johnson, Piscataway..........	61.84	5.37	0.16	1.57
55	“ “	“ “ “ “	44.71	9.00	0.24	2.08
83	Chalky marl.	“ Dr. Chas. Lowndes, Easton..........	18.77	39.90	0.32	0.18
92	Sand and shell marl.	“ Geo. Taylor, Glymont................	67.70	1.88	0.80	1.78
447	Light brown shell marl.	“ J. A. Cunningham, Friendship.......	77.82	8.56	0.44	0.84
448	“ “ marl.	“ P. H. Prout, Friendship.............	82.67	8.00	0.26	0.28
449	Sand marl.	“ J. A. Wood, “	92.23	1.06	0.88	0.59
450	“ “	“ “ “ “	92.19	1.00	0.52	0.23
451	Shell marl.	“ “ “ “	76.62	11.19	0.89	0.22
452	“ “	“ “ “ “	80.28	9.50	0.14	0.42
453	“ “ rock.	“ “ “ “	98.02	....	....	....
454		“ L. M. K. Griffith, Dunkirk..........	83.37	4.25	1.74	0.44
455	Shell marl.	“ “ “ “	84.96	0.56	0.12	0.52
456		“ “ “ “	81.86	trace	0.12	2.49
457		“ “ “ “	80.04	“	0.30	2.40
459	Shell marl rock.	“ “ “ “	96.96	....	....	....
461	“ “	“ E. L. F. Hardcastle, Lee Haven....	38.39	28.37	2.22	0.43
462	“ “	“ “ “ “ “	26.21	31.94	0.30	0.32

536	Light gray, partly decomposed.	"	T. F. Lansdale, Triadelphia..........	.....	trace	trace	0.25
537	" " sandy appearance.	"	" " "	.....	"	"	0.26
585	Shell marl.	"	T. R. Brooks, Seat Pleasant..........	65.48	12.37	0.24	1.41
586	Blue or green sand marl.	"	" " " "	76.11	4.38	0.30	1.84
587	Shell marl.	"	" " " "	69.37	9.88	0.16	1.62
588	Shell marl.	"	" " " "	51.41	22.20	0.16	2.85
589	Shell marl.	"	" " " "	64.54	12.37	0.12	1.39
590	Brown sand marl.	"	" " " "	81.22	1.50	0.20	2.08
591	Blue or green sand marl.	"	" " " "	81.84	1.00	0.20	1.71
592	Shell marl.	"	" " " "	53.34	16.87	0.16	2.29
593	Marl rock.	"	R. S. Mitchell, Glymont..............	36.09	29.00	0.12	0.23
594	White chalky marl.	"	Dr. Chas. Lowndes, Easton..........	13.21	45.88	0.16	0.24
605	Marsh mud.	"	Thos. Hill, Baltimore................	87.57	1.38	0.12	0.23
606	" "	"	" " "	87.34	1.25	0.14	0.22
610	Light gray marl.	"	Dr. Chas. Tilghman, Tunis Mills......	57.58	20.90	0.40	0.29
611	Dark gray marl.	"	" " " " "	74.00	13.12	0.28	0.38
612	Muck.	"	" " " " "	20.88	trace	0.28	0.69
	NEOCENE MARLS.						
1026	Shell marl.	From	Jones' Wharf..........................	46.76	24.55	0.10	0.24
1025	Under No. 1022.	"	Cove Point..........................	67.24	15.30	0.06	1.88
1027	Shell marl.	"	Plum Point..........................	71.43	13.70	0.38	0.72
1021	" "	"	" "	73.08	13.45	0.38	0.31
1022	Yellowish-green marl.	"	Cove Point..........................	73.07	12.15	0.06	0.33
	EOCENE MARLS.						
1107	Shell marl.	From	Bel Alton..........................	65.51	1.25	2.26	4.76
1106	Shell marl, under No. 1107.	"	" "	67.68	5.10	0.29	4.17
1108		"	" "	80.94	0.85	0.45	0.73
1167	Green sand marl.	"	Upper Marlboro......................	75.33	0.45	2.45	2.88
1030	" " "	"	Donaldsonville......................	80.11	10.30	trace	2.71
1019	Shell marl, under No. 1029.	"	Clifton Beach........................	52.93	12.70	0.20	2.36
1028	Green sand and shell marl.	"	Pope's Creek........................	78.25	trace	trace	2.35
1105	Shell marl.	"	Bel Alton	66.00	5.90	0.24	2.34
1079	Green sand marl.	"	Machias Point, Va....................	78.66	trace	trace	1.81
1023	Shell marl.	"	Clifton Beach........................	59.85	11.45	0.16	1.11
1024	Green sand and shell marl.	"	Potomac Creek, Va....................	84.52	0.85	0.08	1.04
1147	" " "	"	Seat Pleasant........................	50.59	9.10	0.16	0.64
879	Green sand marl.	"	T. B..............................	83.46	1.25	0.19	0.59

TABLE XXV—*Continued.*

Laboratory No.	Description and source of sample.	Insoluble matter.	Lime (CaO)	Phosphoric acid P_2O_5	Potash K_2O
880	Green sand marl. From T. B.	91.65	0.90	0.48	0.42
1029	Shell marl. " Potomac Creek, Va.	59.09	17.30	trace	0 33
	CRETACEOUS.				
1146	From Seat Pleasant.	78.11	2.45	0.18	0.65
	UNCLASSIFIED MARLS AND MISCELLANEOUS.				
1166	Lime marl. 20 ft. below surface. Sent by W. G. Worman, Frederick.	8.80	50.10	0 08	0.28
799	Marl from near surface. " George Earle, Millersville.	75 39	12.19	0.48	0.21
798	" " " " " " " "	87 90	1.62	trace	0.38
800	" " " " " " " "	92.90	1.25	"	0.16
1148	Dirt from a well. " W. O. Reeder, Laurel Grove.	76.69	trace	0 29	1.32
878	River mud. " A. T. Parsons, Salisbury.	73 05		0.19	0 39
1169	Shell and sand marl. " J. L. Rowland, St. Mary's county.	82.81	7.37	0.16	0.43
1413	Lime and shell marl. " Alonzo Berry, Williamsport.	0.77	54.75	0.08	0 19
1451	Shell and sand marl. " R. J. Manning, Accokeek.	52.78	15.87	0.08	1.76
1455	Clam shell marl, partly decompos'd " T. B. Dyer, Oxen Hill.	64.28	11 25	0.04	1 81
1456	Sand marl. " " "	89.21	trace	0 28	0.32
1457	Shell marl. " " "	64.28	18.12	0 20	0 40
1458	" " " "	34.21	33 87	0.24	0.34
1459	Sand marl. " " "	77.74	0.05	0.36	0.80
1460	*Bone found in marl deposit. " " "	2.46	.....	30 41	0.40
1541	Decomposed stone. " W. S. Whiteford, Whiteford.	89.92	trace	trace	trace
1726	Shell marl, M. A. E. S.	.....	,,	trace	trace
1730	" " J. B. Hallowell.	22.83	27.25	trace	trace
1731	" " "	29.30	35.25	trace	trace
1738	Shell and sand marl. " Randolph Humphreys, Salisbury.	63.58	2.15	trace	trace
1741	" F. G. Aukum, Washington, D. C.	59.75	7 25	1.40	trace
2075	Shell marl. " Wm. B. Reed, Sr., Centreville.	51.32	24.20	trace	trace
2076	Green sand marl. " " "	70.90	1.20	.....	.....

2117	Shell marl.	"	Edward Lynch, Westminster	69.42	11.60	.....	.....
2129	" "	"	J. J. Collins. Bishopville	68.92	13 64	.....	.....
2516	" "	"	H. Spear, Mason Springs	38.82	29.64	trace	0.37
25 0	" "	"	" "	80.91	9.20	trace	0 23
2572	" "	"	R. C. Booth, Piscataway	.....	16*00	0.32	0.12
2774	" "	"	P. W. Chew, Washington	57 21	21 46	0.62	0.10
2845	" "	"	J. W. Tnompson, Newport	.....	.....	trace	0*87

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* The bones had the appearance of vertebra.

Value of Maryland Marls.

The value of Maryland marls usually depends upon the amount of shells which they contain. The green and bluish marls are not very valuable as they contain but little lime, and the potash which they contain is not very available to crops. Maryland shell marls have very little commercial value owing to the great proportion of worthless material they contain and their bulky nature, but *they have considerable agricultural value* and should be more extensively used than at present. In fact no farmer who has a deposit of shell marl, that is easily accessible, on his place can afford not to use it very generally and quite frequently on his land. Some time the shell marl may not act quite as quickly as caustic lime but in a series of years it will produce as good, and in some cases better results. The following results of experiments which have been conducted at this Station show beyond a doubt that applications of Maryland shell marl will produce very decided increases in the yields of crops.

TABLE XXIV.

Showing Effect of Shell Marl Compared with Other Sources of Lime.

(Yields in bushels and pounds per acre.)

Application.	Quantity, lbs.	4 Crops Corn.		3 Crops Wheat		4 Crops Hay, lbs.	Total 11 Crops.	
		Grain, bu.	Fodder, lbs.	Grain, bu.	Straw, lbs.		Grain, bu.	Forage, lbs.
Nothing	.....	97.5	10400	31.9	2697	5200	129.4	18297
Stone Lime	1400	127.7	11228	33.6	3607	6760	161.3	21595
Oyster Shell Lime	1400	129.9	11440	31.9	2967	8060	161.8	22467
Ground Oyster Shells	2600	148.4	12834	42.3	4095	7930	190.7	24859
Shell Marl*	13000	145.0	11858	43.4	4744	8580	188.4	25182

*The marl used in this experiment was from the same deposit as Sample No. 588, Table XXV.

In another experiment the application of two tons of shell marl per acre produced an increase of 16.7 bushels of corn and 450 lbs. of fodder per acre the first year.

In still another experiment the application of four tons of shell marl per acre did not produce any increase in the first crop of corn, but gave an increase of 3½ bushes of corn and 600 lbs. of fodder the second year and the third year increased the wheat yield 5½ bushels of grain and 1050 lbs. of straw. The marl used in these last two experiments was from the same deposit as sample No. 50, and while this is a fairly good marl yet it should have been applied much heavier than it was for best resuts.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 111. OCTOBER, 1906.

THE OYSTER SHELL SCALE.

Lepidosaphes ulmi Linn.

By T. B. Symons.

The Oyster Shell scale, one of the easily distinguished species of scale insects, is generally distributed over Maryland, and in fact is said to be found practically throughout the world. This scale has received treatment at the hands of writers on injurious insects for many years. Probably the first account of this pest in this country was written by Mr. Enoch Perley, of Bridgton, Me., and was published by the Massachusetts Agricultural Society in 1796. It is supposed to be an imported pest and to first have located in the New England States, but it has spread generally throughout the United States. Though it was never generally considered a very serious pest, yet early writers warned orchardists to be on the lookout for its introduction into their orchards. This insect has not been found to be very injurious to apple orchards in Maryland, with the exception of some few cases in Garrett County. In these orchards the pest has to be combatted with as much vigor as in controlling the San Jose Scale. Although it does more or less injury to various fruit trees, this bulletin is written with a view to calling the attention of the public to the insect's comparatively recent attack on maple trees. The injury being done by this pest to the sugar-maples in many parts of the State is very great, and no means have been employed for its control. Specimens of this scale on various trees have been received from time to time for a number of years; but it is only during the past two years that serious injury has been noted; and of its causing the death of many large maples.

The maple trees, as would be expected, and as shown in the accompanying cuts, are attacted usually in the upper and younger branches. This insect works and multiplies in each direction from the point of first infestation, killing the branches by sucking the juice of the trees, as it progresses. In cases where trees are killed there is no doubt but that they have been infested for some time. This fact illustrates the importance of not only giving fruit, forest, and shade trees, and ornamental shrubbery attention at the time of planting but also of frequently inspecting them.

To the general observer this may not appeal with the forcefulness that it does to the authorities of some of our small towns or to the individual property owner, where the insect has seriously injured or killed outright the great majority of the maple trees and often other shade trees. This condition has been observed in several small towns in this State, and it is only by a concerted effort on the part of their citizens that such a condition can be improved. It should be the duty of the citizens of every village or town to see to it that some officer gives the necessary attention towards the growth, development, and protection of their shade trees; for there is nothing that adds more to the comfort of the inhabitants and the beauty of the hamlet or city than its trees. In our large cities this important feature of municipal supervision is generally provided for. Accordingly the conditions which exist today in regard to the injury by the Oyster Shell Scale to our maple trees, by the San Jose Scale to the fruit trees as well as by other insects attacking various plants in many of our towns, would be prevented.

It may not be inappropriate in this connection, to refer to the war that is now being waged by the people of Massachusetts and New Hampshire against the Gypsy and Brown-tail moths, which pests threaten the annihilation of forest, shade, and fruit trees in parts of these states. While everything possible is being done by the authorities of those states and the United States Bureau of Entomology to prevent the spread of these insects to other states, it is possible at any time that either or both of them may be introduced into Maryland, therefore it is of prime importance that not only should the people at large pay some attention to their shade trees in order to prevent any injury being done by an insect but also towns and municipalities should take vigorous action in the control of any injurious insect pest.

LIFE HISTORY.

The different stages of the insect's life history are shown in the accompanying cuts, figures 1 and 2. Figure 1 shows a female scale from below, revealing the tiny white eggs varying in number from 45 to 90, which are laid in early fall. Her dead body is also shown in the upper end of the scale. The insect passes the winter in the egg state. The eggs hatch early in May in this latitude into tiny young which crawl out upon the small twigs of the tree or bush and at once settle, inserting their beaks into the bark of the food plant. While the young twigs are usually infested yet the scale is often found on the larger twigs and branches and even on the trunks of trees. In the north this insect is supposed to have only one annual generation. In this State, Prof. Johnson reports in Bulletin No. 20, U. S. Div. Ent. 1890, that there are two generations; the young of the second generation appearing the last week in July or the first week in August. Unfortunately we are not prepared to verify this statement at this writing from actual observation. It was intended to study the life history of this insect very closely this past year, but circumstances prevented, and we were only able to observe one single scale that we isolated on a lilac bush. In this case there was only one generation. The rapidity of the increase of the pest indicates, however, that there are probably two generations in this State.

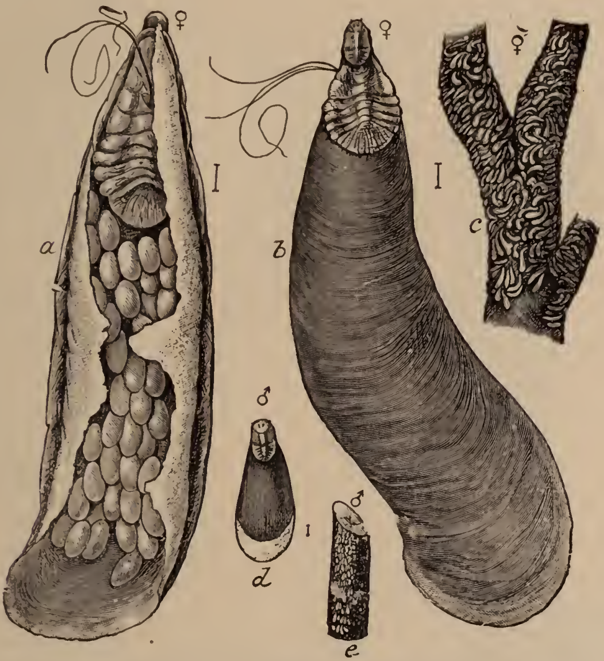

Figure 1—Oyster Shell Scale—(Lepidosaphes ulmi Linn.): a. female scale from below, showing eggs; b. same from above, greatly enlarged; c, female scales; d. male scale, enlarged; e, male scale on twig, natural size. After Howard, Yearbook, 1894. U. S. Department of Agriculture.

After inserting its beak the female molts twice, the molts aiding in the formation of the scale which is secreted mainly from the posterior end of the body. It continues to develop until reaching maturity when it lays the eggs previously referred to for either the second generation or for passing the winter. The male scale is much smaller than the female (see figure 1) there being a single cast skin; and the scale is hinged at its posterior part in such a way as to permit the escape of the winged adult (see figure 2). This winged male however, can do no injury, its only function being to assist in reproduction.

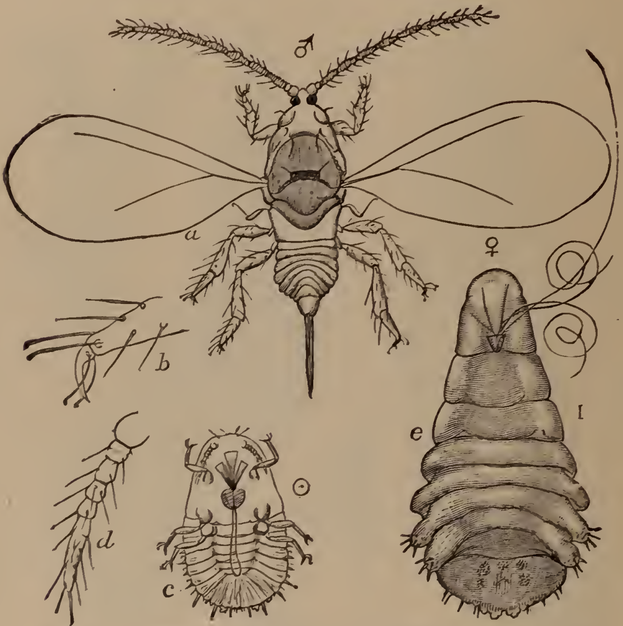

Figure 2—Oyster Shell Scale—(Lepidosaphes ulmi Linn.): a, adult male; b, foot of same; c, young larva: d, antenna of same; e, adult female taken from scale—a, c, e greatly enlarged; b, d still more enlarged. After Howard, Yearbook, 1894, U. S. Department of Agriculture.

FOOD PLANTS.

The Oyster Shell Scale apparently has a great range of food plants. In this State we have observed the insect attacking apple, plum, (see figure 3), pear, quince, silver maple, sugar maple, Norway maple, linden, willow, lilac, poplar. In the Yearbook of the U. S. Department of Agriculture, 1894, Dr. Howard, cited in addition to the above hawthorn, buckthorn, raspberry, currant, hop-tree, bladdernut, horse-chestnut, blackberry and cottonwood as found in the District of Columbia. Some doubt has been expressed as to the correct identification of the species in all cases, as the resemblance of some species is so very close that they will be considered the same upon superficial examination, and it is only a close study of the structural differences that reveals otherwise. The variety of its food plants has aided the

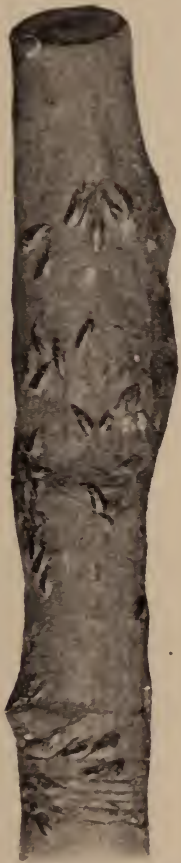

Figure 3—Oyster Shell Scale on maple.
Photo. by A. B. Gahan.

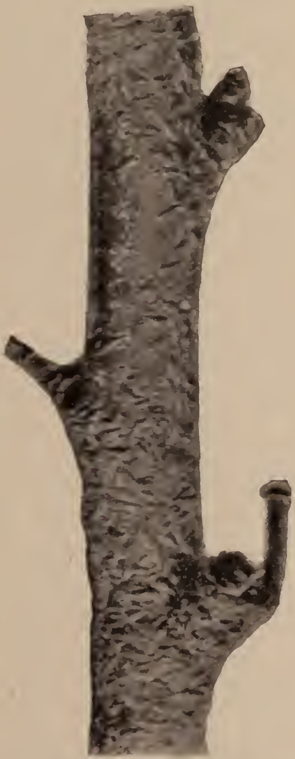

Figure 4—Oyster Shell Scale on plum.
Photo. by A. B. Gahan.

general distribution of this insect over the country. Its injury to various species of maple, lilac, and apple in this State point to the fact that it prefers these food plants in this locality.

EXPERIMENTS ON MEANS OF CONTROL.

As already stated this insect does its injury by sucking the juices of plants and accordingly must be controlled by a contact insecticide. As the insect winters in the egg state, recommendations have not commonly been made for destroying it at that season but it is usually advised treating just as the eggs hatch in early May. This method applies as a general rule, as it is seldom that an insect can be easily destroyed in the egg state. Kerosene emulsion applied just as the eggs hatch has been universally recommended for the control of the pest. This being the best solution to use when the plants are in foliage. However, since the general adoption of the lime, sulfur and salt wash for the control of the San Jose Scale it was suggested and recommended at times to treat plants infested with the Oyster Shell Scale during the dormant season, on the theory that the causticity of the lime, sulfur and salt wash would tend to slough off the scale and thereby expose the eggs to the action of the weather, which would either wash or blow them off. The lime, sulfur and salt wash, when properly applied, remains on the trees well into the summer and will no doubt kill many of the young lice as they are hatched. Again, spraying at the dormant season permits of more thorough treatment and enables the work to be done at the same time that the orchards are being sprayed for San Jose Scale. So far as recorded no direct experiment with the lime, sulfur and salt wash on Oyster Shell Scale on maple trees have been reported. Therefore, owing to the great amount of damage being done by this insect in this State it was decided to test the effect of the lime, sulfur and salt wash applied to maple trees in both the fall and spring and compare it with the kerosene emulsion treatment given in May. The experiments conducted were rather limited in number but the results in each case were quite conclusive.

Credit is due Mr. A. B. Gahan and Mr. W. C. Travers for work in the application of the washes and to Mr. Gahan for taking notes on the same. We also wish to thank the gentlemen on whose places the work was conducted for their cooperation.

Experiment No. 1—November 15th, 1906, eight large maple trees, the smallest eight inches in diameter, at the country home of Mr. Arthur Boehm, near Towson, were sprayed with the lime, sulfur and salt wash 20-15-10 respectively. The trees were badly infested with Oyster Shell Scale, the tops of some of them being killed. Some trees at Mr. Boehm's as well as several on an adjoining property were left as checks. Examination of these trees in early spring and late in August showed that the treatment gave good results, as very few scales could be found on the treated trees, while the untreated ones showed con-

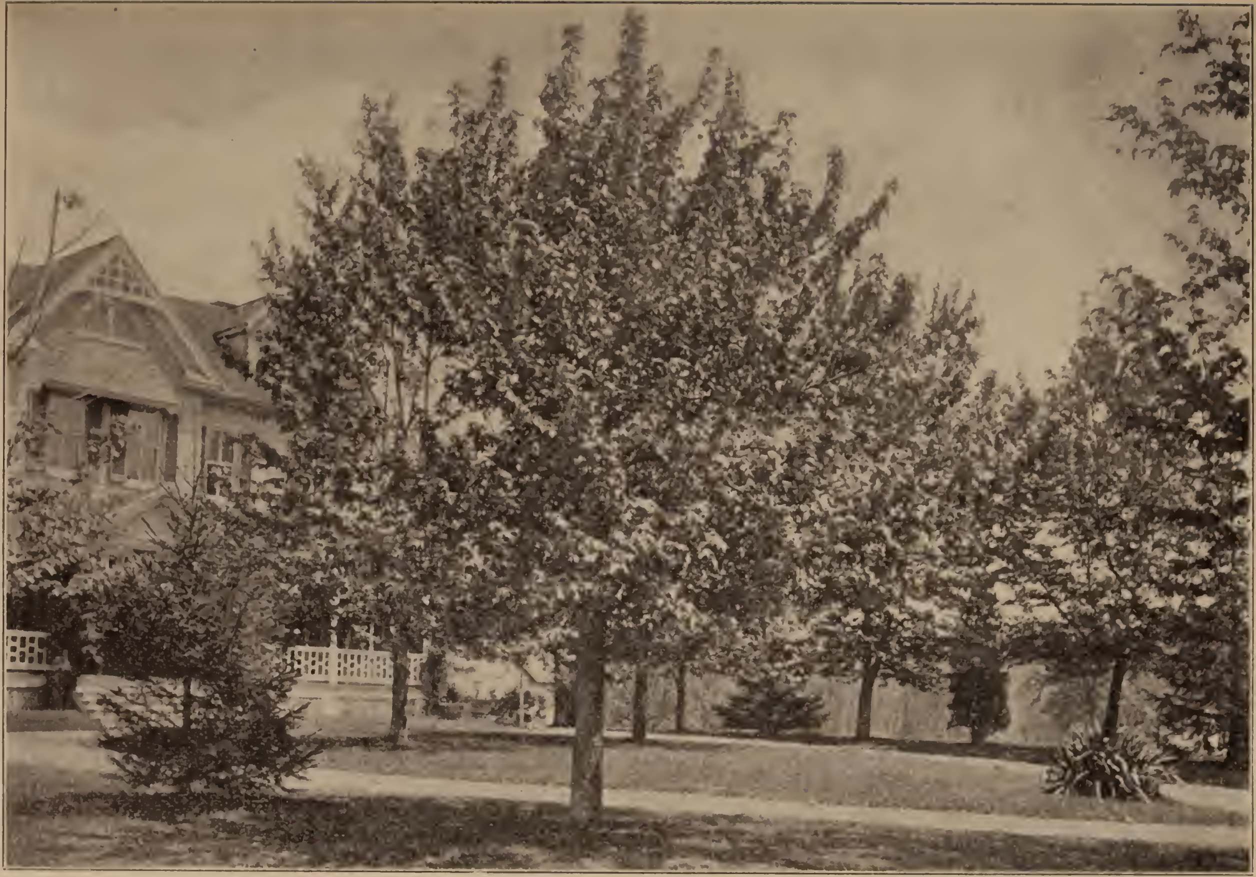

Figure 5—Showing growth of tree in foreground that was severely cut back and sprayed in the fall. Photo. by A. B. Gahan.

siderable increase of the pest. Figure 5 shows the appearance of the trees this summer. Note the manner in which the tree in the foreground has grown after being severely cut back and sprayed in the fall.

Experiment No. 2—To test the effect of the lime, sulfur and salt wash applied in the spring, three large maple trees in the yard of Mr. Zouck at Reisterstown, were treated April 27th, 1906.

Examination of these trees during the summer and fall showed that while the wash gave satisfactory results, the trees were not as clean of the scale as those treated in the fall. This was no doubt due to the fact that the spraying was not quite as thorough on account of weather conditions at the time of the application. There was, however, a striking difference between the treated and untreated trees at this place.

Experiment No. 3—Five badly infested maple trees were sprayed with kerosene emulsion, made with Tak-a-Nap soap, May 7th, 1906, at Mr. Chesney's, Sherwood, Md. The young were crawling quite plentifully at the time of the application.

Examination of the treated trees, June 4th, 1906, showed practically all of the crawling young to have disappeared with only a few having settled on the terminal twigs of one of the sprayed trees, while the checks showed the brood to have settled and developed. Later examination, September 14th, showed the treated trees to be in excellent condition while the untreated ones were badly infested.

DEDUCTIONS FROM THE EXPERIMENTS.

1. That maple trees infested with the Oyster Shell Scale can be treated in both fall or early spring with the lime, sulfur and salt wash with satisfactory results, as regards controlling the pest and without injury to the trees.

2. That where one application is made these tests showed the fall treatment to be preferable. It is the belief of the writer, however, that when the wash is applied thoroughly in early spring equally good or even better results can be obtained.

3. That it is advisable to employ the lime, sulfur and salt wash for the control of the pest, only when it is desired to treat the trees during the dormant season, when they can be sprayed more thoroughly than when in leaf. In cases where this wash is employed for the control of the San Jose Scale, all the spraying of this character can be done at one time.

4. That Kerosene emulsion applied just as the young scale insects are crawling, early in May, is very effective in controlling the insect. Exceptional results were obtained in this experiment. It may be stated that the Tak-a-Nap soap used in making the emulsion is very satisfactory as it dissolves easily in cold water.

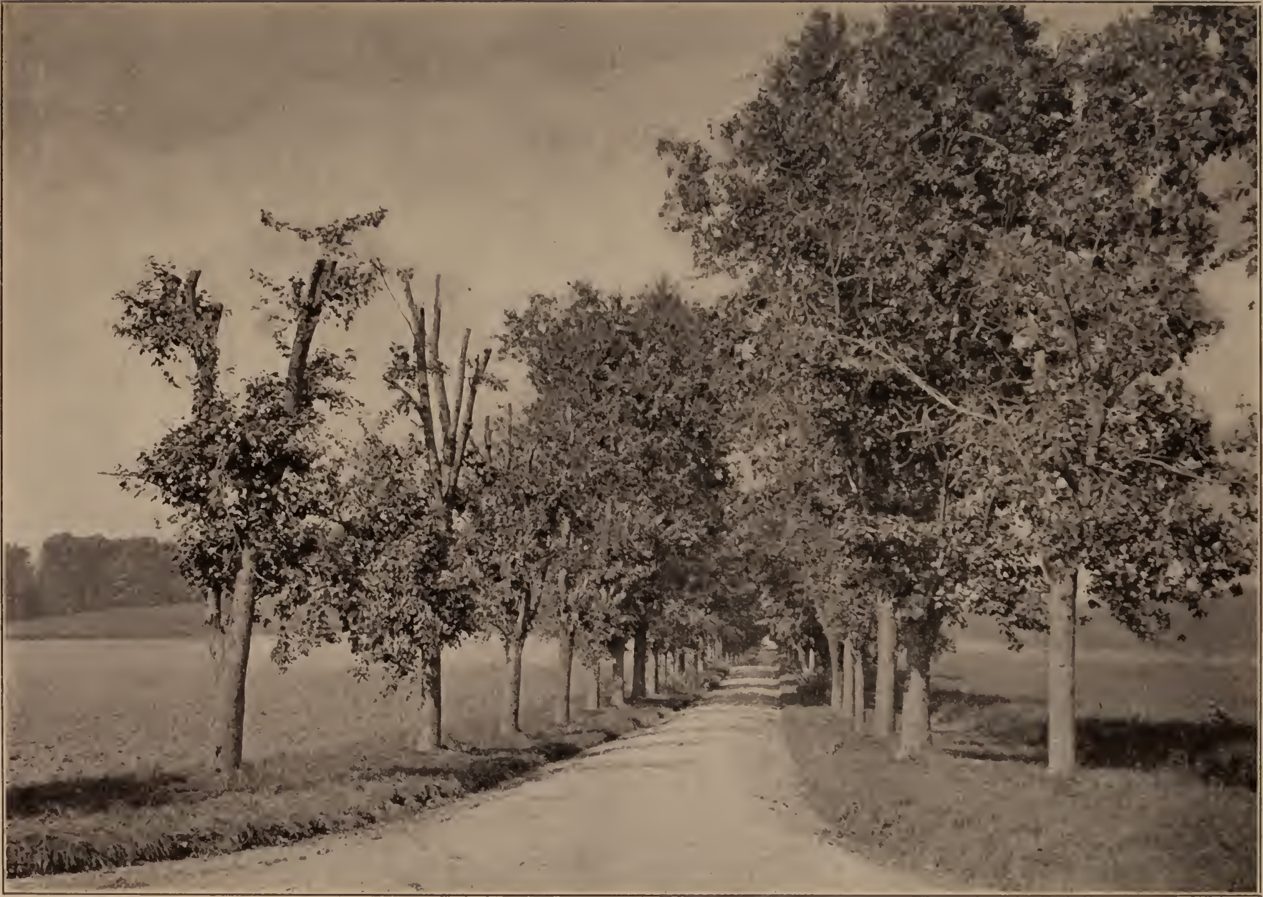

Figure 7—Injured trees cut back, ready for treatment, near Lutherville.
Photo. by A. B. Gahan.

RECOMMENDATIONS.

Inasmuch as this pest has so many food plants the home keeper should be on the lookout for its introduction to his place before it does any serious damage. Where maple trees are infested, the dead parts of the trees should be cut out and the trees sprayed either with lime, sulfur and salt wash while the trees are dormant, or with fifteen per cent. kerosene emulsion, when the eggs hatch in early May and if a second brood of young appears about the last of July or first of August, another application should be made. The insect is not a hard one to combat and it is only in cases of neglect that it reproduces sufficiently to kill the plant that it attacks.

The problem of spraying large maple trees is somewhat difficult, and while they may be treated with a hand pump, the operator climbing the trees in order to reach all parts, it will generally be found advisable to employ a good barrel pump for the work. In treating very large trees it will be necessary to have a high platform and to use long extension rods in order to spray the tops of the trees properly.

KEROSENE EMULSION.

Any desired per cent. of kerosene emulsion in a wash may be accurately secured. The fifteen per cent. emulsion, which should be used in treating trees and plants infested with the Oyster Shell Scale in early May in quantities of fifty gallons should be made as follows:

Water	5 gallons.
Ordinary hard soap*	1½ pounds.
Kerosene (150 degrees)	7½ gallons.

Pour the 7½ gallons of kerosene in the spray pump barrel, slice the soap and dissolve it in the water, which should be heated to the boiling point. Pour the hot water with soap dissolved into the spray barrel and thoroughly emulsify by pumping the mixture back into itself for ten minutes, moving the nozzles around all the while. The emulsion when properly made, should be of a creamy white consistency, and may be diluted with any desired quantity of water, without the oil separating to the top. If 37½ gallons of cold water, making fifty in all are added, there will be a fifteen per cent. kerosene emulson.

NOTE—In our experiments Tak-a-Nap soap, sold by the Thayer Hovey Co., Darby, Pa., was used. In using this soap in making the emulsion it is not necessary to have the five gallons mentioned in formula heated but simply mix the soap with the cold water and then emulsify with the given amount of kerosene. Using this soap saves some trouble in not requiring heated water.

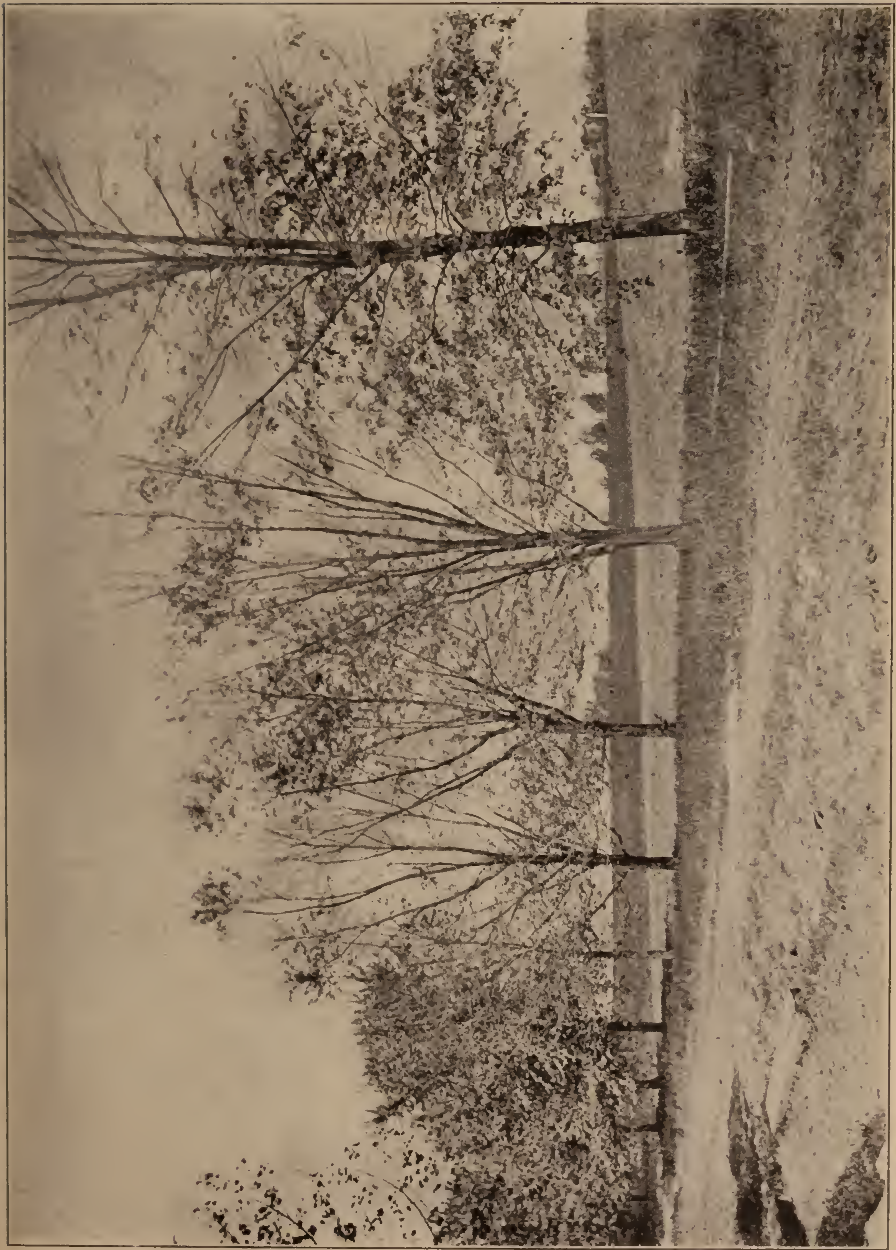

Figure 6—Part of a row of maples, seriously injured by the Oyster Shell Scale. near Towson. Photo. by A. B. Gahan.

LIME, SULFUR AND SALT WASH.

The standard formula for making this wash as employed for the control of the San Jose Scale applied during the dormant season can be used in treating for the Oyster Shell Scale, and is as follows:

Good quality freshly burnt stone lime...........	20 pounds.
Flowers of sulfur or flour of sulfur.............	15 pounds.
Common salt..............................	10 pounds.
Water	50 Gallons.

Put 20 gallons of water in an iron pot or hog scalder and bring it to a boil, and then add stone lime and sulfur. The sulfur should have been made into a paste with hot water before placing it in the boiler, in order to facilitate its mixing. After the lime and sulfur have been boiled for sometime add the salt. Boil the mixture, stirring occasionally, from 30 minutes to one hour, or until the sulfur is thoroughly dissolved and produces a clear amber colored solution. Then dilute by adding sufficient hot or cold water to make 50 gallons. Pass the mixture through a strainer with at least 20 meshes to the inch, into the spray barrel and apply to the trees warm.

Figure 8 shows a very convenient boiler for making the wash, in addition this form of boiler is very handy on a farm for other purposes, and it is relatively inexpensive. A fuller description of this kind of boiler including plan and measurements, and of the lime, sulfur and salt wash will be given in a forth-coming bulletin of this Experiment Station.

For applying this solution select a good spray pump that has all its working parts brass and furnishes a constant high pressure. Use any of the nozzles that are suitable for applying kerosene emulsion or Bordeaux mixture.

The spraying is somewhat disagreeable and the solution is slightly corrosive, so that the man doing the work should be provided with rubber or oilskin coat, hat and gloves and a pair of goggles. It is a good plan to rub vaseline on the hands and face to prevent the spray solution from irritating the flesh. The horses attached to the spray wagon should be covered with blankets or old sacks. The aim should be to spray thoroughly and see that every part of the tree is covered. In order that this may be done with facility the hose should be long enough to enable the man to reach all sides of the tree without moving the barrel. Trees which have been thoroughly sprayed present a whitened appearance when dry. After drying it is easy to detect the parts that have been missed, and these should be gone over.

There are a great many kinds of spray pumps on the market and each person must select that which suits his taste and needs.

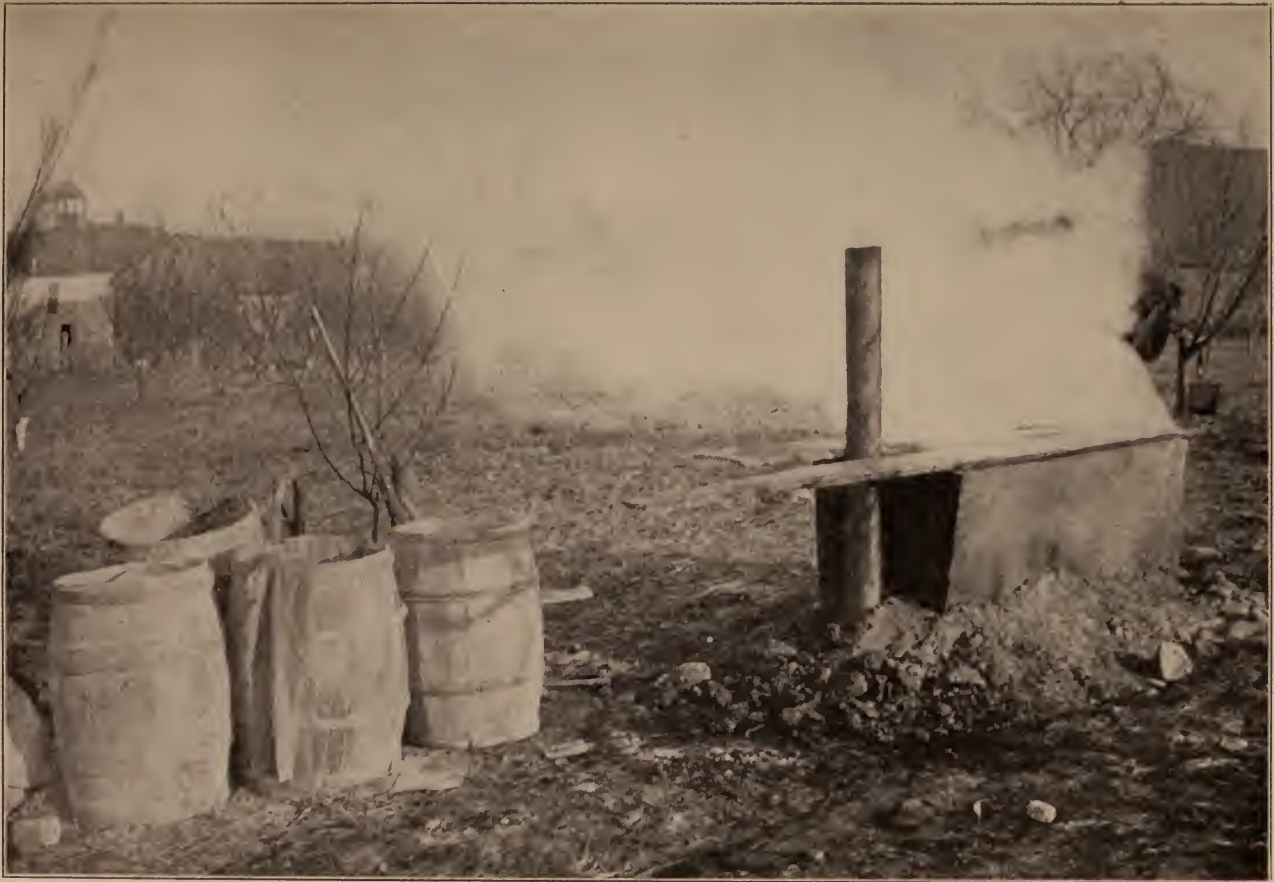

Figure 8—A cheap and convenient way of making the lime, sulfur and salt work.
Photo. by A. B. Gahan.

The following are manufacturers and dealers in pumps and supplies:

F. W. Bolgiano & Co., 935 B St., Washington, D. C.
Field Force Pump Co., Elmira, N. Y.
Gould Mfg. Co., Seneca Falls, N. Y.
Griffith & Turner, Baltimore, Md.
Morrill & Morley, Benton Harbor, Mich.
Myer Pump Co., Ashland, Ohio.
L. G. Orndorff, 203 7th St., N. W., Washington, D. C.
Spray Motor Co., Buffalo, N. Y.
Geo. H. Stahl, Quincy, Ill.
The Deming Co., Salem, Ohio.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 112. NOVEMBER, 1906.

TREATING SAN JOSE SCALE.

RESULTS OF EXPERIMENTS CONDUCTED IN 1906.

By T. B. Symons and A. B. Gahan.

The constant demand for up-to-date information in combatting the San Jose scale makes necessary this publication, based upon the results of experiments conducted by this Department during the past year, upon co-operative experiments with the Bureau of Entomology, United States Department of Agriculture, and also upon general observations in this and in other States.

It is generally conceded that the business of fruit growing can be conducted at this time with as much, and even more, success than previous to the advent of the San Jose scale in the State. The pest has required orchardists to give the trees closer attention, and in doing this, they have observed other needs that they had hitherto neglected. Better general culture and fertilization, together with a greater interest in the control of other injurious insects and plant diseases have resulted. In addition, the insecticide generally employed for the control of the pest, viz., lime, sulphur and salt, is decidedly beneficial to the health of the trees. The result has been a tendency to produce a better quality and larger quantity of fruit which demands a more remunerative price.

Again, the San Jose scale is a source of advantage to the up-to-date orchardists, in that it is forcing out of competition the ones who do not give their trees proper attention, and who market a class of fruit which tends to bring the price below a profitable basis. In order to reap the benefits of this advantage, however, it is necessary that the grower exercise constant vigilance in the care of his orchard.

The phase of the control of the San Jose scale to be considered at this time is, therefore, what is the best wash that the progressive orchardist can apply to his trees, keeping in mind effectiveness, general health of the trees, cost, and difficulty of application? It is, indeed, a strange characteristic of the general public, and especially of those engaged in the various branches of agriculture, that, after procuring satisfactory results from a certain remedy, article of machinery, seed or plant, they are prone to employ something *new*, which has not been given a practical test under the many varying conditions which always exist. Far be it from our wish to convey the thought of discouraging experimentation in any phase of activity, but let those who wish to employ new insecticides employ them as an experiment on a comparatively small area, and not leave the fate of their whole orchard in the hands of a "quack salesman." One should only employ such untried insecticides in treatment of cases where no effective remedy is known. In the case of the San Jose scale, we have an effective means of control, and this should be employed until entirely satisfied by practical demonstration that a new preparation has distinct advantages over the old.

GENERAL CONDITIONS IN THE STATE.

It can be stated with all assurance that the progressive orchardists of this State have no difficulty in controlling the San Jose scale. There are, however, any number of comparatively small orchards in the State owned by men not especially interested in fruit growing that are serving as distributing points for the pest to a greater or less extent. It is the duty of the State Entomologist to seek out and abate such nuisances, by the enforcement of the State Horticultural Law. This duty is being performed in cases which come to our notice, and the inspection of orchards is being carried on in so far as our limited appropriation will permit. While there is a marked advance in the treatment of infested orchards in the State, yet there is much room for improvement. The inspection and enforcement of the law is not carried nearly so far as the officers of the State Horticultural Department would desire, yet all that is possible under our present means is being done.

HEDGES.

One serious factor contributing to local infestation in many parts of the State is the Osage orange hedges. It is very evident in certain districts, where hedges are generally employed as fences, that they aid materially in the dissemination of the pest, as hedges are the favorite gathering places of many birds and the birds are the principal means of distribution of the scale. It is only rarely that one finds one of these hedges that is not a harbor for the San Jose scale; practically every one examined in the State has been found infested. One unfortunate feature is that the hedge is so hardy, that the pest, though killing many parts and causing it to present a ragged appearance, seldom kills it outright; therefore, it stands as a continual menace in distributing the pest in any vicinity.

In the writers' opinion the Osage orange hedge is an undesirable fence, under any conditions, but especially so when it becomes a menace by harboring pests. The accompanying picture (Fig. 1)

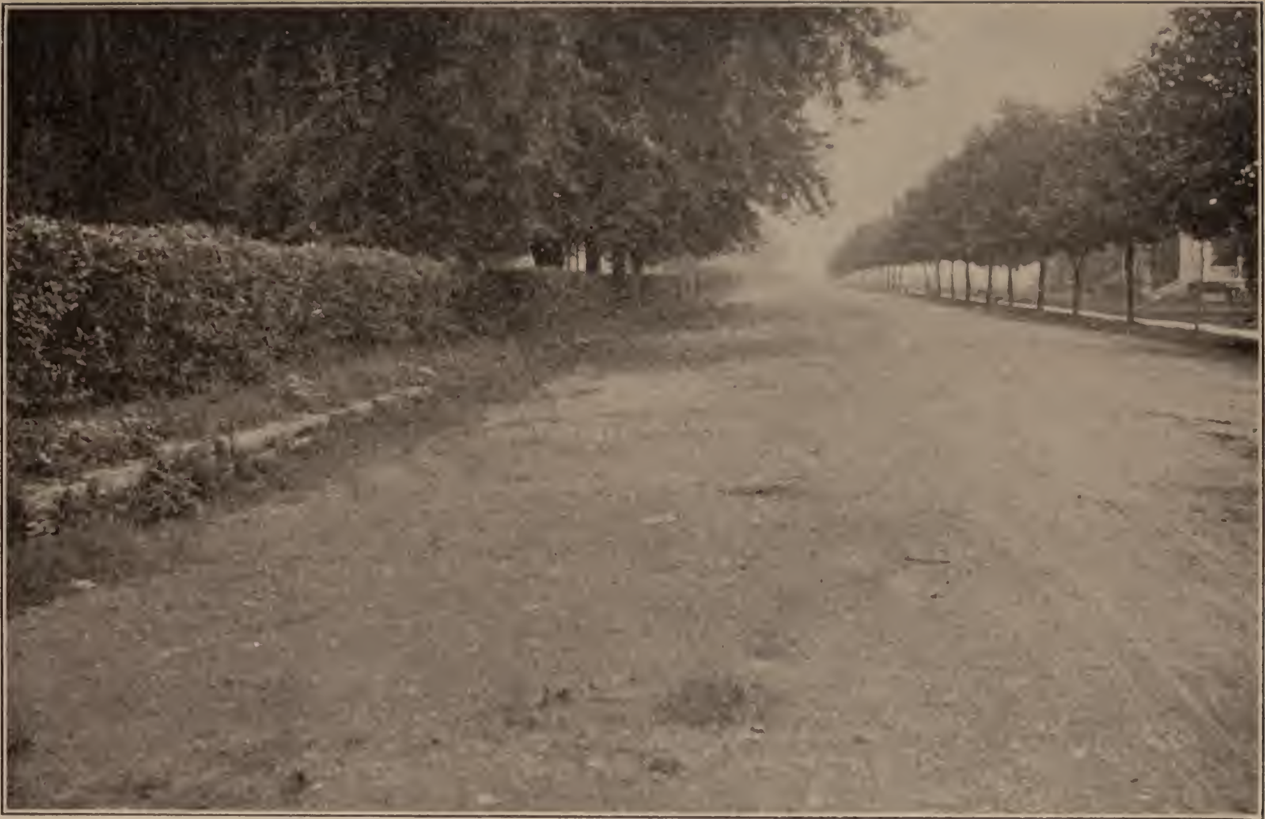

Figure 1.—An Osage orange hedge, seriously infested with San Jose scale, within the limits of Frederick City. Photo. by T. B. Symons.

shows a hedge which apparently presents a good appearance, yet is badly infested with the scale. It will be necessary for orchardists and general farmers to spray the hedges on their farms with the same regularity displayed in treating the orchard. It will also be necessary for the law to be enforced in treatment or destruction of hedges, as well as with neglected orchards. It may be stated here that the hedge should be treated while dormant, with the lime-sulphur or other effective insecticides.

EXPERIMENTS.

The experimental work herein detailed is to some extent a continuation of that recorded in Bulletin 107 of this Station. Several new principles are involved, however, viz.: (1) A comparison of single treatments in fall and spring and a double treatment, one application being made in the fall and one in the spring; (2) the relative value of flowers and flour of sulphur: (3) the ascertainment of whether the lime-sulphur treatments can be relied upon for apple trees or not, it having been asserted that apple trees cannot be effectively treated with these mixtures. In order that our experiments might demonstrate the truth or falsity of this proposition, we secured mostly apple orchards for our work the past year. All told, about 840 apple trees and 540 peach trees were used, making a total of 1,380 trees in the experiments. As formerly, we secured, as far as possible, orchards that were badly infested, but that had not yet been badly damaged.

The orchards were located as follows: 200 apple trees belonging to Gardiner Bros., at Jessup; 140 apple trees belonging to Mr. Robert Owens and 50 peach trees belonging to Mr. R. O. Shipley at Harmans; 250 apple belonging to Mr. J. B. Ennis; 100 apple belonging to Mr. Miller, and 100 peach belonging to Mr. Millard at Laurel; 360 peach and 100 apple belonging to Mr. E. E. Martz, Boonsboro, and 50 apple belonging to Mr. E. Wade, Passadena.

The orchard of Mr. Ennis was the same one treated in 1905, in co-operation with the Bureau of Entomology, United States Department of Agriculture, and which had become quite badly reinfested from the check plots (one on each side of the orchard), and from three or four plots that in the 1905 experiments were treated with weak or poor mixtures that did not kill the scale. The co-operation of the United States Department was continued in the treatment of this orchard in 1906 and was extended also to the orchards of Mr. Owens and Mr. Shipley, at Harmans.

DETAILS OF EXPERIMENTS.

The experiments comprise tests of the following combinations of lime and sulphur; lime, sulphur and salt, and lime, sulphur and caustic soda.

(1) 30 lbs. stone lime, 25 lbs. sulphur (flowers), 50 gal. water boiled 1 hour.
(2) 25 “ “ “ 20 “ “ “ 50 “ “ “ 1 “
(3) 20 “ “ “ 15 “ “ “ 50 “ “ “ 1 “
(4) 20 “ “ “ 15 “ “ “ 50 “ “ “ 2 “
(5) 20 “ “ “ 15 “ “ “ 50 “ “ “ ½ “
(6) 30 “ air slaked lime, 15 lbs. “ “ 50 “ “ “ 1 “
(7) 40 “ stone lime, 15 lbs. “ “ 50 “ “ self boiled
(8) 20 “ “ “ 15 “ “ 10 lbs. salt,50 “ “ boiled 1 hour.
(9) 30 “ “ “ 15 “ “ 6 lbs. caustic soda, 50 gals. water.
(10) 20 “ “ “ 15 “ “ 10 “ “ “ 50 “ self boiled
(11) 15 “ sulphur, 10 lbs. caustic soda, 50 gals. water.

Numbers 2, 3, 4 and 5 were duplicated, using the flour of sulphur, several plots being treated with these washes. As in 1905, several patent insecticides were included in the experiments, viz.: Scalecide, Kil-o-scale and Target Brand Scale Emulsion.

The co-operative work at Laurel with the Bureau of Entomology of the Department of Agriculture consisted of the application in the fall only of washes made according to formulas 1, 2 and 3. Eighty-six trees were treated in the fall only, 70 receiving both fall and spring treatments, and 65 spring treatments only. The trees of each lot were divided as equally among the three different washes as practicable. The co-operative work at Harmans and Jessup consisted of the application of all of the eleven above-mentioned formulas to both peach and apple and also included plots of apple sprayed with the three patent insecticides mentioned.

RESULTS OF DIFFERENT TREATMENTS.

Lime-Sulphur Mixtures.

These washes were almost uniformly successful—so nearly so, in fact, as to make it exceedingly difficult, if not impossible, to draw conclusions, as to the comparative values of the different formulas. As formerly, the mixtures to which external heat was applied in the preparation were more successful than those prepared by means of the heat generated by the materials themselves. The plot of 10 trees at Jessup, sprayed with formula 7, in which the lime alone was depended upon to furnish heat, gave quite unsatisfactory results. Notwithstanding 40 pounds of a good quality of stone lime were employed, not enough heat was generated to dissolve the sulphur, and, as a consequence, most of it remained in the free state, giving a very weak wash.

Formula 6, in which air-slacked lime was used, also gave very poor results on apple in our own experiments; but it may be said that in one case coming under our observation a peach orchard was treated by a private party with the same mixture and quite satisfactory results obtained. These conflicting results seem to indicate that air-slacked lime is not as dependable as the stone lime, but that it may be used as a makeshift substitute for the latter.

In all our former publications in regard to the lime-sulphur washes the use of the flowers of sulphur has been recommended. The question having arisen as to whether the cheaper grade of sulphur, known as flour, would not serve as well, several experiments designed to determine the compartive effectiveness of washes made from the two grades were undertaken. As stated above some solutions were made up, substituting flour of sulphur for the flowers of sulphur in formulas 2, 3, 4 and 5 and trees sprayed with each. Over 150 trees, including both peach and apple, were treated with these washes, the trees being about equally divided between the four preparations. A comparison of these plots in September failed to establish any advantage in favor of the more expensive grade of sulphur.

These results, combined with former observations on this point, and as the flour is somewhat cheaper than the flowers, besides less given to lumping and, therefore, easier to mix into a smooth paste, lead us to say that either grade of sulphur mentioned may be used in making the lime-sulphur wash.

Very little difference was manifested between the mixtures cooked a half-hour and those receiving a longer cooking—what little advantage there was being in favor of the longer cooking. The results from the mixtures cooked a half-hour were quite satisfactory, only one or two live scale being found on any plot in September. Most of the mixtures receiving an hour or more of cooking gave perfect results, i. e., no live scale could be found when the summer breeding period was over. This is the more remarkable when we consider that most of the trees upon which these washes were used were apple, which are supposedly harder to successfully treat than peach.

Regarding the attempt to determine the comparative effectiveness of fall only, fall and spring both, and spring only treatments, it can only be said that all of these treatments proved so thoroughly effective as to leave no basis for comparison. Examinations in September of Mr. J. B. Ennis's orchard, in which these experiments were carried out, showed the treatments in every case to have resulted practically in extermination.

In this connection mention should be made of the fact that the fall applications were made quite early (October 30), and the spring applications quite late (April 3) in the dormant season. Thus the fall application found the scale not yet completely dormant and for that reason more susceptible to treatment, while the washes put on so late in the spring were still adhering to the trees when the scale again became active.

There can be no doubt that the time of application had a great deal to do with the success of these treatments. Previous to this year the late application has proven superior in all experiments conducted by this department, no doubt because it remains on the trees well into the breeding season and prevents the young of the few females that manage to escape the spray from finding a place to settle

It is still our opinion that a late spring treatment is preferable, but where the orchardist finds it impossible to put off the spraying until that time, owing to other duties, he will very likely find it advantageous to do the work as early in the fall as possible, without injuring the trees. This should be about October 30.

Considering what has been said regarding the success attending the use of the lime-sulphur washes the past season and bearing in mind that a majority of the trees sprayed were apple, it will quite naturally be inferred that the wash is an entirely efficacious treatment for apple as well as peach. However, a doubt is cast upon the correctness of this conclusion by the variableness in results of similar experiments upon apple in former seasons as well as by the indifferent success of some orchardists who have used it, and the experience of other experimenters along the same line. The rough bark and hairy terminal shoots of the apple afford the scale a hiding place in which it is protected from the wash and thus a few will manage to escape a thorough application. Nevertheless, while the results of lime-sulphur seem not to be so uniformily successful upon apple as upon peach, it has proven quite satisfactory in most cases, much more so than any of the other washes tried.

Several attempts have been made to ascertain whether increasing the amounts of lime and sulphur would not render it more effective. If an opinion were to be based entirely upon the past season's work, it would be that the ordinary strength used for peach will prove satisfactory in the treatment of apple, it having given good results upon the one as well as upon the other. Further, no difference could be noted between the efficiency of this strength and the stronger solutions. However, in the spring of 1905 about 250 apple trees were sprayed in co-operation with the United States Department of Agriculture, Bureau of Entomology, with mixtures ranging from normal (i. e., 20 pounds of lime and 15 pounds of sulphur to 50 gallons of water) up to 35 pounds of lime and 30 pounds of sulphur to 50 gallons of water, with the result that the stronger washes were apparently slightly more successful than the normal. Taking account of these results and also of the fact that spraying the past season for the San Jose scale has been more completely effective than usual (owing to climatic conditions, as will be later explained), it seems advisable to again recommend increasing the amounts of lime and sulphur in the normal formula, each five pounds, as a precautionary measure where badly infested apple trees are to be treated.

LIME-SULPHUR AND SALT.

Only two plots were sprayed with mixtures in which salt was an ingredient making about 70 peach and 30 apple. The results in both cases were perfect, but, as has been said, perfect results were also obtained from washes in which no salt was used, so that there appears to be no advantage in its use. This simply bears out our former recomendation in Bulletin 107.

LIME-SULPHUR AND CAUSTIC SODA.

Two plots, comprising about 10 apple trees each, were sprayed with solutions 9 and 10 respectively In both cases the lime and caustic soda were depended upon to furnish the heat. In No. 9 the lime was first slacked with the sulphur and the caustic soda afterward added, while in No. 10 the sulphur was first made into a paste and the caustic soda added to the paste, causing the sulphur to dissolve. The liquid was then used to slack the lime. The latter method gave much the better-looking solution, but no difference was discernible in the results obtained from the two solutions. Both were fairly satisfactory, only a few live scale being left in each case, showing, as in former experiments, that the self-boiled mixtures in which caustic soda and a good quality of stone lime are used can safely be substituted for the heat prepared mixtures, where apparatus for cooking by external heat is not available.

SULPHUR-CAUSTIC SODA.

A solution made according to formula No. 11 was sprayed upon about 10 trees at Jessup. The sulphur was mixed into a paste and dissolved by the addition of the caustic soda and then diluted. Like the foregoing self-boiled solutions, this one gave fairly good results, but as the number of trees was small and the past season an exceptional one, no great significance should attach to so limited a trial.

KEROSENE LIMOID.

The results of our 1905 experiments with this mixture, not having entirely accorded with the findings of some other experimenters we concluded to give it another trial. Accordingly, 30 peach and 10 apple trees at Boonsboro were treated with a 20 per cent. emulsion on April 11th. The peach were quite badly infested; the apple but slightly. When examined in September, these trees were all in very good condition, only a few live scale being found on the plot. Undoubtedly the lateness of the application, combined with the open winter, and fine weather following the spraying, account to some extent for this seeming reversal of our 1905 results. In view of the fact that the 1905 experiments with this wash were much more extensive than those of this year and of the further fact that the past season has been an exceptional one as regards the effectiveness of spraying for the San Jose scale, we are not yet convinced of its desirability as a substitute for lime-sulphur.

PATENT INSECTICIDES.

Kil-o-scale and Scalecide. Not having been thoroughly convinced by our former work with Scalecide and Kil-o-scale, that these preparations were wholly ineffectual, it was decided to try them again. Accordingly, plots at Jessup and Laurel were treated with each and also about 50 trees with Scalecide at Boonsboro. It was intended to treat a similar number of trees at the latter place with Kil-o-scale, but through some mistake of the express company the material failed to arrive in time for use. In these experiments two strengths of each preparation were used, viz: that recommended by the manufacturers and double that recommended. At double the recommended strength good results were obtained from each, the sprayed trees being free from scale in September, except one lot at Boonsboro, upon which Scalecide was used. No doubt the failure at this place was due to the fact that the oil did not emulsify properly, owing to the presence of some lime in the spray barrel which had just previously been used for applying lime-sulphur and salt.

At Laurel, both Kil-o-scale and Scalecide used at the recommended strength, viz: one part of the preparation to twenty parts of water, failed to give satisfactory results, as did also the former when used at the same strength upon twenty-five trees at Boonsboro. At Jessup, both gave apparently good results when used at this strength. It may be said, however, that at the latter place, check trees were left for comparison and these showed the scale to have multiplied to but a very slight extent even where left untreated.

TARGET BRAND SCALE EMULSION.

This preparation, which is a miscible oil similar to the two noted above, has not before been mentioned in publications of this Department, it being given its first trial the past season. One hundred and ten trees including both peach and apple at Boonsboro, thirty apple trees at Laurel and ten apple trees at Jessup were sprayed with it at the recommended strength and also five trees at Jessup with double that strength. Like Scalecide and Kil-o-scale, this preparation gave satisfactory results at the lesser dilution. Diluted according to directions, it gave good results on one plot (that at Jessup), but was quite unsatisfactory on the large plot at Boonsboro, and very poor on the one at Laurel. These results are too variable to warrant definite conclusions without further trial.

On the whole, experiments the past season have been slightly more favorable to the patent miscible oils than formerly. As has already been stated, however, the past season has been an exceptional one as regards the success of spraying for the San Jose scale. Examination of untreated trees in early spring showed about the usual per cent. of the pests to have survived the winter, but the extremely mild and open winter weather may have prevented their becoming as completely dormant as usual, thus rendering them less protected and consequently more susceptible to injury by the sprays. Certain it is that never before have any of the washes given such uniformly satisfactory results, as were indicated by the fall examinations. Undoubtedly, the frequent and heavy rains during the breeding period helped to some extent in the excellent showing made by most of the sprayed plots by washing the young scale from the trees before they could become securely fixed. Even the trees left untreated as checks in most cases did not show the usual multiplication of the scale during the summer. Taking into consideration the above facts together with the poor showing made by these washes when used at the recommended strengths upon the plots at Laurel and Boonsboro, it seems unsafe to attach much significance to the apparently good results obtained from them on the cooperative plots at Harman's. Used at the double strength they gave uniformly fair results, and orchardists contemplating using any of the mixtures would do well to bear this in mind. As formerly, however, it is the opinion of the writers that orchardists should be extremely careful and conservative about substituting any patent insecticide for the lime-sulphur wash which has so many times proven its reliability as a remedy for scale, and also in an efficient remedy for some fungous diseases. If any proprietary mixture continues to give satisfactory results we will be pleased to recommend it, cost, effectiveness, and other things being equal. For the present, however, we would advise anyone contemplating use of any of the above mixtures to at least double the strength recommended by the manufacturers.

DIRECTIONS FOR MAKING LIME-SULPHUR WASH.

In consideration of this wash we find from the reports of other experimenters, as well as from the results of our experiments for the past four years, that many variations in the quantities of each material used, and also many methods of boiling the wash, give uniformly satisfactory results. There is, therefore, considerable range both in quantity of materials and methods of making, which is decidedly a favorable factor in any insecticide, for seldom do farmers do similar work by the same methods and seldom do people interpret written directions or even speech in the same light, so that it is well that this wash will give good results under a variable interpretation of the directions for making and applying. As a whole, however, from the various combinations employed in our experiments with the mixture, we believe the following formula and directions for making to be the most satisfactory.

Stone lime	20 lbs.
Flowers or flour of sulphur	15 lbs.
Water to make	50 gallons.

NOTE:—While we do not consider salt a necessary ingredient of the wash, yet 10 pounds can be used if desired.

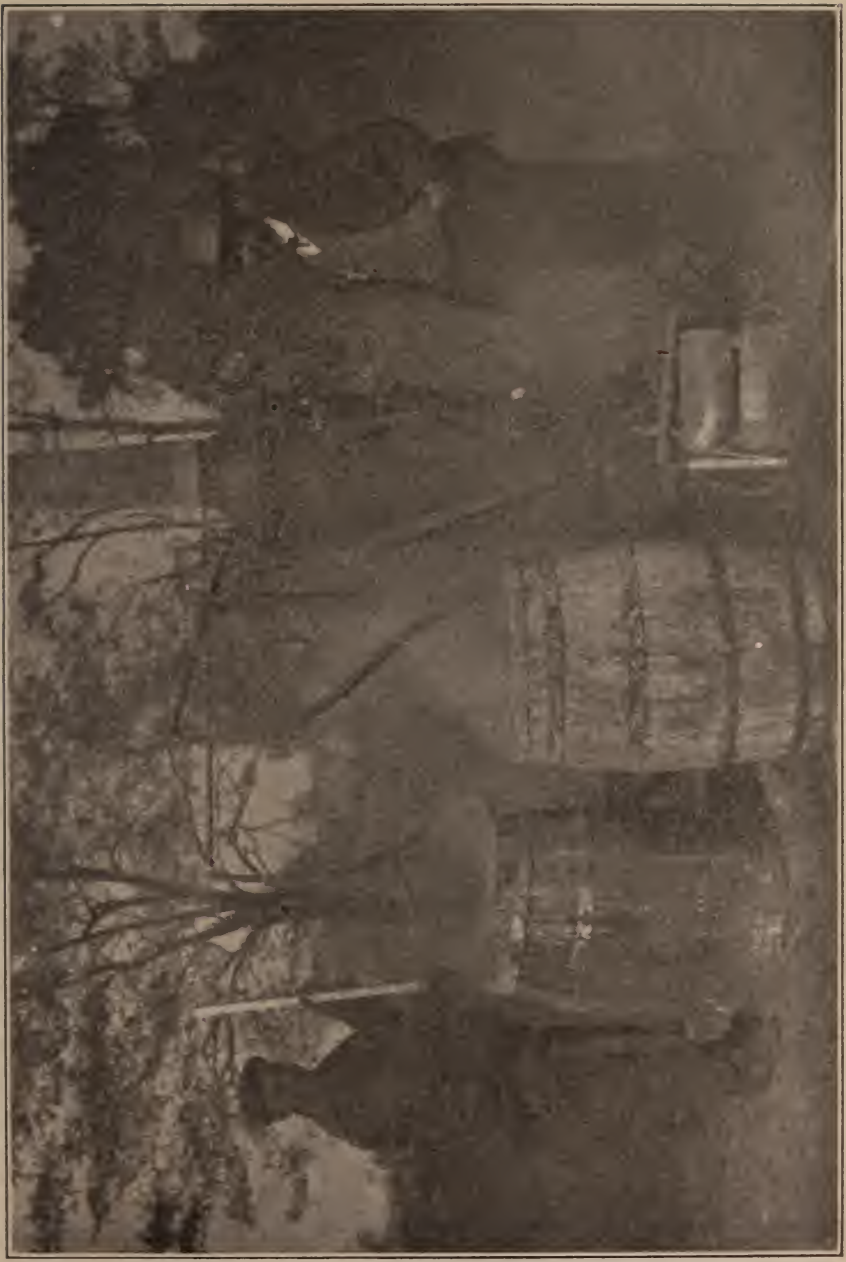

Figure 2.—Making lime-sulphur wash by steam. Photo. by Geo. P. Weldon.

Put twenty gallons of water in an iron vat or hog scalder and bring to a boil, then add the stone lime and sulphur. The sulphur should be made into a paste with hot or cold water before placing it in the boiler, in order to facilitate its mixing. After the lime and sulphur have been boiled for some time, salt may be added if desired. Boil the mixture, stirring occasionally, from thirty minutes to one hour or until the sulphur is thoroughly dissolved and a clear amber-colored solution produced. Then dilute by adding sufficient hot or cold water to make fifty gallons. Pass the mixture through a strainer with at least twenty meshes to the inch, into the spray barrel and apply to the trees warm.

BOILING THE WASH BY STEAM.

Owners of large orchards usually find it more convenient and less expensive to cook the wash by steam. In some cases an ordinary engine is hired or an ordinary boiler employed. In this manner, several

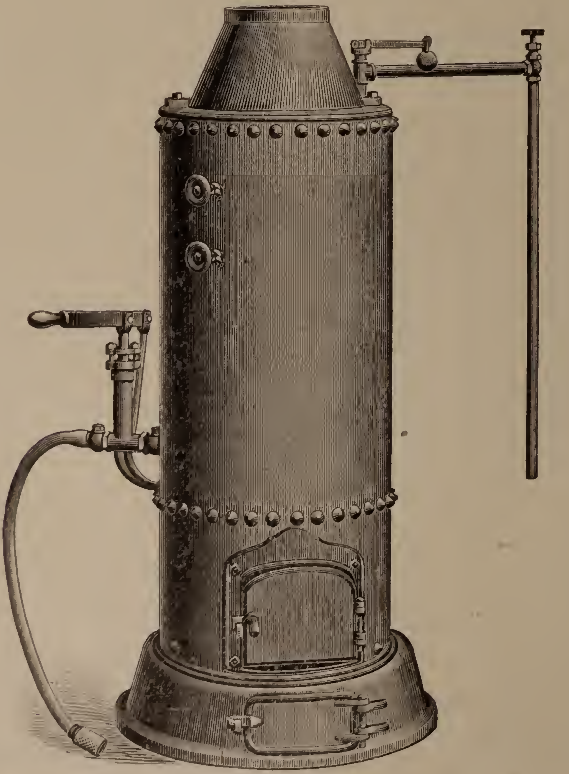

Figure 3.—Boiler for making the lime-sulphur wash by steam. Courtesy of Griffith & Turner, Baltimore, Md.

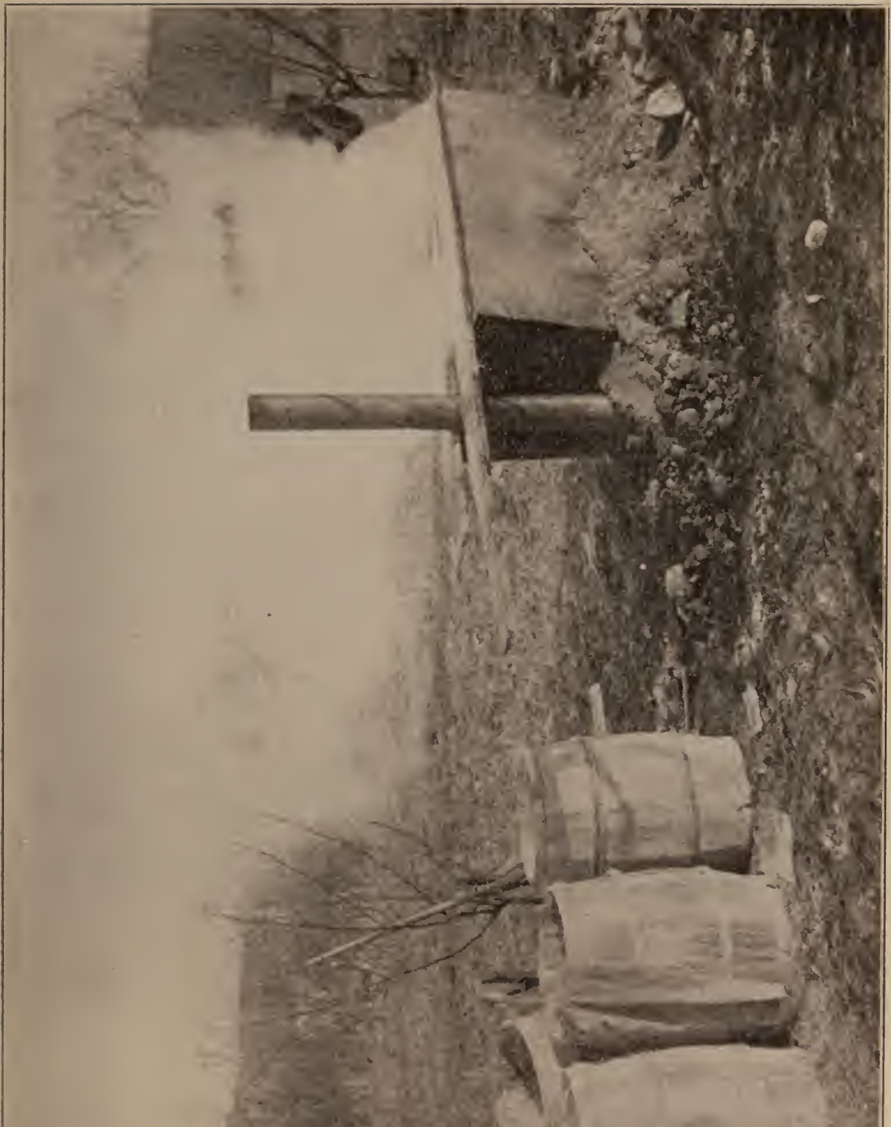

Figure 4.—A cheap and convenient way of making the lime-sulphur wash. Photo. by A. B. Gahan.

barrels of the wash can be made at the same time which facilitates the work where more than one pump is in operation. The steam pipe is extended along the top of the barrels, a branch pipe extending down into each barrel. This method of boiling the wash is not out of reach of the comparatively small orchardist, as a small, steam food-cooking boiler can be secured for about thirty dollars, which will serve to cook two or three barrels at a time. Figure 2 shows one of these small boilers, set up for work. It will be seen that the boiler is mounted on a truck and can be wheeled around to any place in the orchard or on the farm. There is no doubt that such an arrangement is very handy in making the wash and is not very expensive. The accompanying cut, Figure 3 shows one of these boilers.

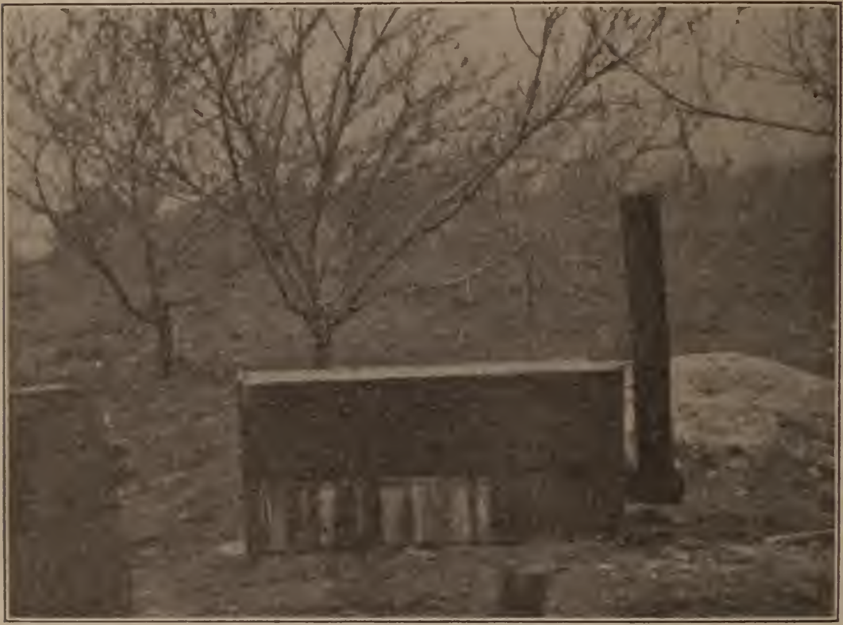

Figure 5.—Convenient vat for preparing lime-sulphur wash.
Photo. by T. B. Symons.

BOILING THE WASH IN A VAT.

The cheapest apparatus that can be employed for boiling the wash is that shown in Figures 4 and 5. Figure 4 consists of an old bath tub set in brick work with space for wood underneath. Figure 5 is a vat, the ends and sides of which are wood and the bottom sheet iron. The accompanying drawing, Figure 6, gives some idea of the dimensions and manner in which it should be built,

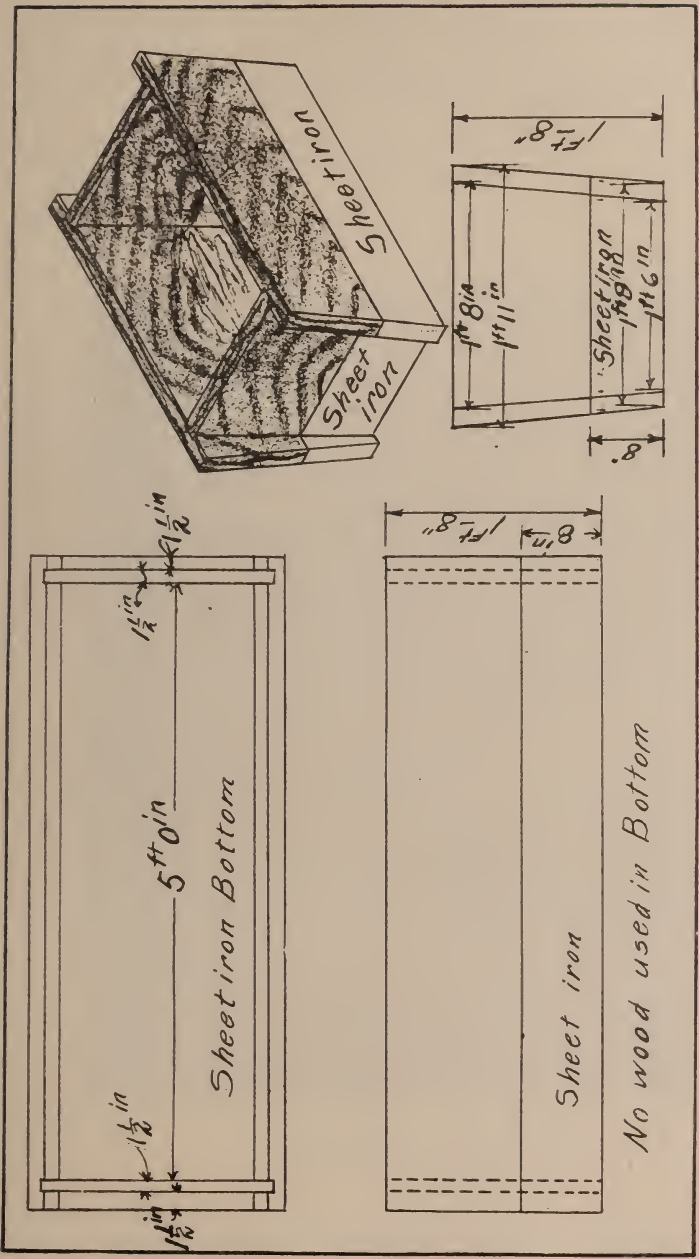

Fig. 6 Detail drawing of Vat.

This vat can be built for about $6.00 depending on the quality and the thickness of the lumber used. It is best to use at least 1½ inch stuff, 20 inches wide. Do not use two widths of boards on sides and ends. The sheet iron should not cost over $2.00. Be sure to allow the sheet iron to extend up the sides at least 6 inches, and especially on the end where fuel is put in the fire.

This vat can be placed over a hole in the ground about one foot deep and extending the whole length of the vat and fitted with a chimney of stove pipe at one end to carry off the smoke. Some orchardists prefer making a fire box out of sheet iron, having no top (as shown in Figure 7, with the vat at the side of the fire box) and setting

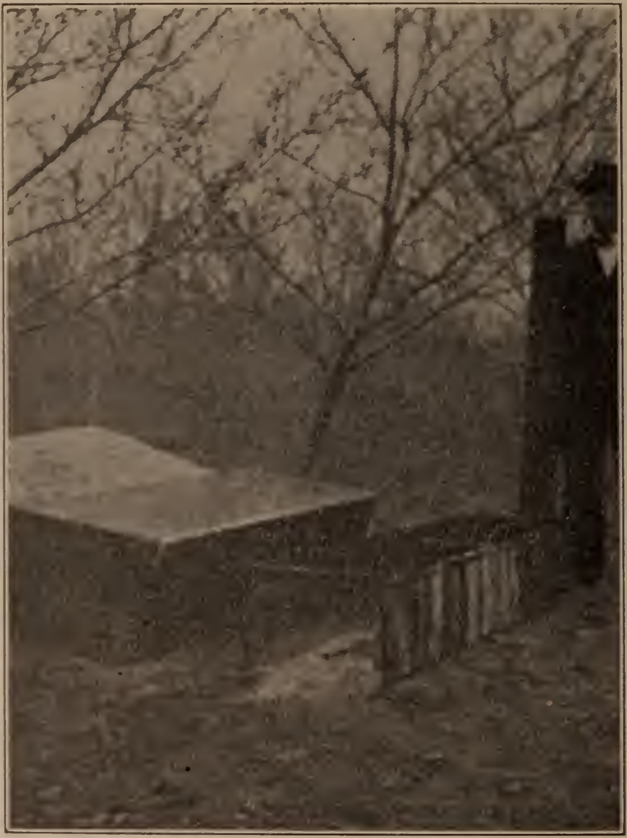

Figure 7.—Showing sheet-iron fire box.
Photo. by T. B. Symons.

the vat on this instead of making a hole in the ground. The fire box and vat shown in the figure, cost the owner, Mr. H. R. Fuss, of Union Bridge, Md., $4.00. Taking in connection the use of such an arrangement on the farm for other purposes, we believe it is the cheapest and most satisfactory apparatus for boiling the lime-sulphur wash.

DIRECTIONS FOR MAKING LIME, SULPHUR AND CAUSTIC SODA.

When it is impracticable to cook the solution as described above, one can be made as follows without cooking which can be expected to give fair results.

Formula:

Good quality, freshly burned, stone lime	20 lbs.
Flowers or flour of sulphur	15 lbs.
Caustic soda	10 lbs.
Water	50 gallons.

Mix the sulphur with a small amount of water to form a paste, then add the lump caustic soda gradually to the sulphur paste. When the sulphur is all dissolved, pour this solution with enough water to keep from burning upon the stone lime, and allow the same to thoroughly slake, keeping the heat confined as much as possible by placing a sack over the barrel. Dilute with cold water to make 50 gallons and strain into the spray barrel.

TIME OF APPLICATION.

As stated in the discussion of this year's experiments, we were unable to draw a conclusion from the results of the washes applied at different times during the dormant season, as all were uniformly effective. However, it is our opinion, based on observation during the past four years, that when only one application is made, the treatment should be deferred until as late in the spring as possible, owing to the fact that the effectiveness of the wash depends to a great extent upon its presence on the trees after the breeding season begins. In bad infestations, especially on apple trees, it is best to make two applications, one in the fall and the other in the spring just before the buds open. In all cases, of course, the solution should be applied while the trees are comparatively dormant. However, in cases of necessity, those having very large orchards and extra work to do in the spring can do the spraying in the early fall when there is usually good weather for spraying, or it may be done on fine days during late winter.

MODE OF APPLICATION.

Not only should this wash be made properly, but the results to be expected depend largely upon the thoroughness of application. The scale being distributed over all parts of the tree makes it necessary that all parts of the tree be sprayed with the solution. It is always advisable to be particularly careful that the terminal branches and twigs of infested trees are coated as the young insects invariably locate on the tender wood. Often it is necessary to touch up these parts after the spray has dried on the trees. This is one advantage of the lime and sulphur wash, that the trees show as if whitewashed after treatment and many parts missed can be easily detected.

Where infested trees have been found here and there in an orchard, the scale is in all probability much more generally distributed than an inspection would ordinarily indicate. Under these circumstances, the whole orchard should be sprayed.

The majority of the spray pumps on the market will give satisfaction. In selecting a pump it is desirable to get one with all its working parts brass and which permits a constant high pressure in addition to being as simple in mechanism as possible. We believe the most economical pump, even for large orchardists, is the barrel pump, sold by various firms the names and addresses of whom will be given.

Where power or double acting spray pumps are desired, they also can be secured from the firms listed below. It is advisable to secure catalogs from all of them and select the pump best suited to your tastes and needs. The same may be said of selection of nozzles,—the desire being to have a nozzle that will throw a fine, mist-spray and one that is easily cleaned. Also in ordering a pump, make it a point to order sufficient hose, at least twenty-five feet to a lead. This will facilitate the work in allowing the sprayman to reach all sides of the trees without moving the pump and barrel. In addition it is usually desirable to have extension rods of either iron or bamboo to attach to the hose.

Applying the lime-sulphur wash is somewhat disagreeable unless the sprayman is properly fitted out with rubber or oil-skin coat, hat and gloves. It is a good plan to rub some vaseline on the hands and face, to prevent the spray from irritating the flesh. If the proper apparatus is used, there need be no more trouble in spraying trees with this solution than with other insecticides.

The following are manufacturers and dealers in pumps and supplies:

Griffith and Turner, Baltimore, Md.
Goulds Manufacturing Company, Seneca Falls, N. Y.
The Deming Company, Salem, Ohio.
Morrill and Morley, Benton Harbor, Mich.
Field Force Pump Co., Elmira, N. Y.
Myers Pump Co., Ashland, O.
George H. Stahl, Quincy, Ill.
Spray Motor Company, Buffalo, N. Y.
L. G. Orndorff, 203 7th St., N. W., Washington, D. C.
F. W. Bolgiano and Co., 935 M St., N. W., Washington, D. C.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 113. DECEMBER, 1906.

TOMATOES.

TESTING VARIETIES, CULTURE, TRAINING AND SPRAYING.

By T. H. White and W. R. Ballard.

Introduction.

The tomato crop, being a very important one in this State, has always received considerable attention at this Station. Several bulletins and reports have been published, all of which are now exhausted. While it is the intention of the present report to give the details of experiments only since the year 1897, still it has been thought well to include the summaries of the work published in former bulletins. While the work primarily has been that of testing varieties and spraying with Bordeaux mixture as a preventive of blight, still there are one or two other important items that have cropped out as the work progressed, and these will be considered in the proper place.

A few observations upon methods of culture have been included for general information.

Tomatoes, like many others of our cultivated plants, being the product of many generations of high culture and selection, must have suitable conditions for their development in order to be a profitable crop. There is no doubt that more of the new and profitable varieties originate under average or medium conditions than in the extremes, either way. It would hardly be expected that a good variety would originate on very poor soil. Neither would this be likely to occur on very rich soil, because of the tendency toward excessive vegetative growth.

Since this condition would apply as well to the general crop, the aim should be to secure average conditions. Land that would produce from ten to twelve barrels of corn per acre should, other things being properly looked after, easily produce six to eight tons of tomatoes. This would be called average or medium conditions.

SOIL.

Almost any soil from sand to clay will produce good crops of tomatoes, but here again extremes should be avoided and except under special conditions, such as where very early markets are to be supplied, it will be better to avoid the very light sandy soils. The soil must be in a good state of cultivation. Manures, fertilizers, lime, and the growing of clover or other legumes all help to bring about this condition. If a sod field is to be used, plow in the late fall or early spring and replow, cutting but a shallow furrow, in time to prepare for planting. Do not plant tomatoes on a piece of land which has had corn upon it the previous year, but rather let corn follow the tomatoes and later wheat or some other grain crop with grass and clover. Many farmers expect to get good tomatoes upon thin, sour land. Blight and disease in unfavorable seasons are always rampant upon such land and the grower becomes discouraged and is convinced that his soil is unsuitable for the crop, when, in reality the failure is due to a condition readily rectified by the application of lime and manure.

LOCATION.

For early market purposes hillsides banked on the North by woods and gently sloping to the Southward will give the best results, but for the general crop for canning purposes the location is not important provided the soil is well drained. It is well, however, to avoid low pockets of land where the air drainage is poor and into which, if the nights happen to be cool and moist, the dampness will settle, forming heavy dews, a condition not only liable to induce leaf diseases but also to prove detrimental to the ripening and dissemination of pollen. A full crop of fruit is absolutely dependent upon a good set and, if the air could be dry at all times it would go a long way towards insuring pollenization, the desired end.

MANURES AND FERTILIZERS.

It is almost impossible to give explicit directions for the proper manuring of a tomato field. This is largely a question of previous treatment and must come from a knowledge of the land and from the experience which the grower has had in handling it.

Stable manure at a dollar per ton is probably the cheapest fertilizer known. This at the rate of twenty (20) tons to the acre can be plowed down in the fall in a fresh state or rotted and applied before replowing in the spring. If the supply of stable manure is limited it can be used in smaller quantities in combination with commercial fertilizers and often give better and more economical results than by the exclusive use of either of them. If stable manure is out of the question commercial fertilizers may be used and if applied on a sod field that has been fall-plowed will give excellent results.

The best way to obtain a reliable fertilizer is to buy the materials and to mix it at home. In most cases a fertilizer that will analyze in nitrogen, phosphoric acid and potash relatively about the same as barn-yard manure will give the best results. See, however, that some of the nitrogen is in a form readily available, preferably in nitrate of soda. Some of the ingredients that can be used to make fertilizers at home are:

Phosphoric acid.	Nitrogen.	Potash.
Dissolved phosphate rock.	Nitrate of soda.	Muriate of potash.
Raw bone.	Sulphate of ammonia.	Sulphate of potash.
	Dried blood.	Kainit.
	Tankage.	
	Dried fish.	

Formula for mixing:

Dissolved phosphate rock	600 pounds.
Dried blood or tankage	900 pounds.
Nitrate of soda	300 pounds.
Muriate of potash.	200 pounds.
	2000 pounds.

This mixture would analyze approximately:

Nitrogen	6%
Phosphoric acid	4 to 5%
Potash	5%

This is a good formula for use without manure and should be applied at the rate of 500 pounds to 750 pounds per acre. Part of it should be sown over the land with a drill and harrowed in, and part in the furrow before the list is thrown up for setting the plants.

If the land has been well enriched with manure all that will be necessary is to supply some readily available plant food to give plants a start. A good formula for this would be:

Dissolved phosphate rock	175 pounds.
Nitrate of soda	100 pounds.
Sulphate of potash	25 pounds.
	300 pounds.

This quantity should be applied per acre. It should be applied in the furrow before listing. If it is found more convenient to use raw bone meal or sulphate of ammonia in the first formula, these may be substituted for the dissolved S. C. rock and nitrate of soda, but for sowing in the row on manured land the second formula will be found preferable.

SEED.

It pays to have good seed from good stock and if possible it will be well to procure the supply from the originator's own growing. There is no doubt that a variety which has passed from the originator's hands and into the hands of ordinary seed growers, who are not familiar with the ideal type as first selected, is sure to change it and perhaps for the worse. Therefore, if the originators are growers, try to get seed from them.

GROWING SEED.

To growers who save their own seed, and this may be profitably done in most cases, attention is called to the fact that careful notice should be taken of a few plants that seem to be just the type that is wanted and seed saved from these. The practice of picking out all the large and finest fruits is not recommended, because very often when the fruit is large the yield is not proportionately so. An illustration of this occurred a few years ago. The tomato called "Enormous" (see table VIII) was sent out. The plant was not at all branching, the stem and foliage being thick and heavy. The blossoms came in clusters of two, of which usually only one fruited. As a result the fruits produced were comparatively few in number but of large size, averaging throughout the season eight ounces apiece. This gave a yield of something less than two tons per acre. On the other hand, the variety "Freedom" which was small fruiting, but quite branching and free flowering in habit, gave fruits averaging three ounces in individual weight and over twelve tons per acre.

The necessity of care in the selection of the plant rather than the fruit is therefore quite apparent.

METHODS OF GROWING PLANTS.

There are two methods in general use in the production of tomato plants to be set in the fields about May 10. The hotbed method is used entirely for early crops. Wooden boxes or frames so-called are set up upon a pile of fermenting material, usually horse stable-manure, which is covered with an inch or two of rich soil. Seed is sown from the first of February to the first of March. The boxes are covered with glazed sash which are daily lifted to allow the plants a proper amount of air in order to produce stocky plants, which when three or four inches high are transplanted into other frames of rotted manure and rich soil. No heating material is used in the transplanting beds; as with some night cover the sun gives sufficient heat. Plants are set four to six inches apart each way and are quite large by the time the weather is suitable for planting out. They may then be cut out with a four inch block of soil and set in the field.

The other method of growing plants in the open air is simply a matter of selecting a suitable location, generally in the shelter of some big woods. The plot is carefully cleaned and prepared by plowing in a quantity of short well-rotted manure. A quick acting fertilizer is then applied and chopped or raked in. Pathways or alleys are marked, leaving beds about four feet wide upon which the seed is sown thinly broadcast. If plants come too thickly they should be thinned as they are weeded. Tobacco-bed sheeting or plant-bed cloth must be used to keep away the small flea-beetle which will do untold injury in the cool dry weather of early spring. These plants are pulled as soon as the weather is settled in May and set out with a peg or dibble on the prepared lists.

The experiments and observations of the past few seasons at this Station plainly indicate that a transplanted plant set out the 10th of May will yield almost double that of the later sown plant pulled from the seed-bed and set out on the same date. The latter part of recent summers have, however, been very wet and the early grown plants have had the advantage of the drier weather in the early summer months in which to bloom and set fruit. Whether, on an average, the hotbed method of growing plants would give the greater yield is a question that will take several experiments to decide. Even then it is questionable whether it would be possible to make it a paying investment as it would take quite an extensive outlay for glass in which to transplant plants enough for a large acreage.

DISTANCE APART.

This depends somewhat upon the variety and the method of cultivation to be followed. If the variety is only a medium grower, like "Sparks' Earliana" and is to be trained to a stake or a pole, one foot apart in the row and four feet between the rows will be satisfactory. If the ordinary culture is followed and the plants allowed to trail naturally over the ground, two and one-half feet apart in the row and three and a half to four feet between the rows will be about right. With the larger growing varieties two feet apart in the rows and four feet between the rows will be required for poles and four by five feet for ordinary culture on land that will produce eight or more tons per acre, while thinner land than this can be set four by four or three by four. Check rows should be made as this will save labor in cultivating. The wide way of the rows should be arranged to suit the run of the field in order that the pickers may gather the fruit without tramping on the vines.

CULTIVATION.

If the soil is moderately stiff and has in it very little fibre from rotten sod or manure so that it is inclined to become hard and compact between the time of preparation and the first cultivation it may be made mellow and friable by the use of the mould-board or barshare plow throwing the earth away from the row both ways, then working by means of cross cultivation with the toothed cultivators. Cultivation should be continued both ways as late as possible without injuring the plants.

SPRAYING EXPERIMENTS.

So much has been said, written, and indeed proved by experimenters about the increased yields and improved qualities of not only tomatoes, but also other vegetable and fruit products, that it seems scarcely necessary to enlarge upon the subject here. There is no doubt that under favorable conditions a fair crop annually is reasonably sure without spraying. In any event spraying is a preventive measure rather than a cure and must be commenced early in order to be effective. Spraying will not prove satisfactory if the soil is unsuitable, poorly fertilized, or low and wet.

The experiments recorded here are a continuation of similar work reported in Bulletin No. 54.

The seed for the year 1898 were sown in the cold frame April 8, and set in the field May 25. The plots contained 100 square feet with five plants to a plot. The plants on the sprayed portion received one application in the seed bed and two in the field. It is shown by Table I that the sprayed plot had a very large proportion of green fruit at the end of the season, the spraying evidently keeping the plants in a growing condition for a longer period than those which were unsprayed. The sprayed plots gave a heavier yield of ripe fruit.

TABLE I.--TOMATO SPRAYING EXPERIMENTS, 1898. SIZE OF PLOTS 100 SQ. FT.

VARIETIES	Sprayed						Unsprayed						Increase or Decrease of Yield on Sprayed Plots, Ripe Fruit, Tons
	Ripe Fruit					Green Fruit	Ripe Fruit					Green Fruit	
	Date of First Picking	Date of Last Picking	Number of Fruits Per Plot	Average Weight of Fruits, ozs.	Yield Per Acre in Tons	Yield Per Acre in Tons	Date of First Picking	Date of Last Picking	Number of Fruits Per Plot	Average Weight of Fruits, ozs.	Yield Per Acre in Tons	Yield Per Acre in Tons	
1 Prizetaker	9/12	10/21	107	4.4	6.1	8.0	9/5	10/21	103	3.9	4.1	.3	+1.9
2 Royal Red	9/20	10/21	89	4.0	4.8	8.0	9/5	10/21	64	4.5	3.9	1.2	+ .9
3 Stone	9/12	10/21	68	6.1	5.7	8.7	9/20	10/21	48	3.8	3.0	1.3	+2.7
4 Favorite (G. & T.)	9/5	10/21	128	4.0	6.6	7.0	9/12	10/21	144	3.6	6.7	2.3	— .1
5 Paragon	9/20	10/21	64	5.8	5.0	6.7	9/12	10/21	51	5.8	3.9	3.5	+1.5
6 Beauty	9/5	10/21	103	3.8	5.3	7.0	9/12	10/21	48	4.8	3.1	3.4	+2.1
7 Matchless	9/5	10/21	83	3.8	4.4	5.5	9/5	10/21	91	4.1	5.5	2.4	—1.1
8 Favorite (Liv.)	9/5	10/21	82	4.2	4.7	7.9	9/20	10/21	93	4.1	5.2	5.2	— .5
9 Golden Queen	9/5	10/21	129	3.1	5.5	5.7	9/5	10/21	133	4.4	7.9	2.7	—2.4
10 Buckeye State	9/5	10/21	180	3.7	9.2	6.4	9/5	10/21	115	2.5	4.0	1.5	+5.2
11 World's Fair	9/12	10/21	80	4.5	4.8	6.3	9/12	10/21	67	4.1	3.7	2.2	+1.1
12 Queen	9/12	10/21	88	5.0	6.0	4.1	9/12	10/21	41	5.2	2.9	2.7	+3.6
13 Imperial	9/12	10/21	89	4.1	5.0	5.2	9/20	10/21	84	3.4	3.9	2.1	+2.1
Aver. for all varieties	......	......	91	4.3	5.6	6.7	......	......	83	4.1	4.4	2.4	+1.3

The seed in the year 1899 was sown in the hotbed March 4, pricked out into cold frames April 5, and set into the field May 12. Table II shows an increase of over one ton per acre on the sprayed portion. The results of the two years work are in accord with the work done previously and the indications are that spraying could be made profitable.

TABLE II.—TOMATO SPRAYING EXPERIMENT, 1899. SIZE OF PLOTS 40 SQUARE FEET EACH.

	VARIETIES	Sprayed					Unsprayed					Increase or Decrease on Sprayed Plots, Tons
		Date of First Picking	Date of Last Picking	Number of Fruits	Average Wgt. Fruit, Ozs.	Per Acre, Tons	Date of First Picking	Date of Last Picking	Number of Fruits	Average Wgt. Fruit, Ozs.	Per Acre, Tons	
1	Stone	7/8	8/21	122	4.0	16.8	7/24	8/21	146	3.9	24.7	—7.9
2	Beauty	7/24	8/21	99	4.5	15.2	7/24	8/21	74	4.5	11.4	+3.8
3	Imperial	7/18	8/21	78	5.0	13.5	7/18	8/21	76	4.0	10.3	+3.1
4	Royal Red	7/18	8/21	98	5.0	16.8	7/18	8/21	70	5.0	12.2	+4.7
5	New Favorite	7/18	8/21	78	3.7	9.9	7/18	8/21	57	3.9	7.6	+2.3
6	Burpee's Climax	7/18	8/21	75	3.5	9.1	7/18	8/21	79	4.1	11.1	+1.9
7	Turner's Hybrid	7/18	8/21	61	5.4	11.4	7/18	8/21	62	5.1	10.9	+ .4
8	Perfection	7/24	8/21	62	3.6	7.6	7/18	8/21	40	4.8	6.6	+ .5
9	Paragon	7/18	8/21	101	2.7	9.5	7/18	8/21	66	3.5	8.1	+1.3
10	Acme	7/24	8/21	70	4.1	10.2	7/24	8/21	31	3.0	3.2	+6.9
11	Ignotum	7/18	8/21	63	3.9	8.4	7/18	8/21	106	3.2	11.6	—3.2
12	Crimson Cushion	7/24	8/21	56	8.0	15.2	7/24	8/21	37	5.8	7.4	+7.8
13	Fordhook Fancy	7/8	8/21	75	2.8	7.2	7/8	8/21	56	2.7	5.2	+1.9
14	Matchless	7/18	8/21	74	4.2	14.2	7/18	8/21	94	4.2	13.7	+ .4
15	Long Keeper	7/18	8/21	105	3.2	11.2	7/18	8/21	68	3.3	7.7	+2.5
16	Truckers' Favorite	7/18	8/21	81	3.6	10.3	7/18	8/21	78	4.7	12.7	+2.4
17	Enormous	7/18	8/21	32	7.4	8.9	7/31	8/21	21	7.1	5.1	+2.9
18	Ex. Ey. Purple Advance	7/18	8/21	150	2.2	11.2	7/24	8/21	110	1.9	7.5	+3.6
19	White's Excelsior	7/24	8/21	82	4.1	11.5	7/24	8/21	76	4.4	11.4	+ .2
20	Combination	7/8	8/21	72	2.7	6.8	7/8	8/21	69	3.3	7.8	—1.0
21	Freedom	7/8	8/21	138	2.5	11.9	7/8	8/21	114	2.5	9.8	+2.2
22	The Early Bird	7/28	8/21	214	1.5	11.5	6/28	8/21	176	1.9	10.7	+ .8
23	Buckeye State	7/24	8/21	57	6.1	11.9	7/24	8/21	72	5.0	12.4	— .5
	Aver. of all varieties	....	....	88	4.0	11.9	....	....	77	3.9	9.7	+1.6

Some varieties seem to be much more susceptible to blight than others so that in 1901 a variety of this character, Sparks' Earliana, was planted to test the value of spraying with the Bordeaux mixture. Table III gives the record of this experiment and shows a large increase in favor of spraying both on poles and under ordinary culture.

TABLE III.—Spraying Experiment with Sparks' Earliana Tomato, 1901.

	Sprayed		Unsprayed		Difference in Favor of Spraying	
	Tons	Pounds	Tons	Pounds	Tons	Pounds
Trained on poles	30	463	25	1790	4	673
Ordinary field culture..	14	410	9	209	5	201

TRAINING EXPERIMENTS.

This experiment was an investigation as to the relative value of the methods of culture, "Trained to a single stem on poles," vs. "Ordinary field culture." The plants trained on the poles had all the side shoots kept off and the main stem tied to a pole. These plants were set three feet apart in the row and four feet between the rows. Those under ordinary field culture were set the same distances apart as those on the poles, but were allowed to run at will upon the ground. The season was a very poor one and but little fruit set. Although Table IV shows less fruit to the plant on the poles than on the plants under ordinary cultivation, they weighed somewhat heavier.

TABLE IV.—SHOWS YIELDS OF VARIETIES TRAINED TO ONE STEM ON POLES VS. ORDINARY FIELD CULTURE, 1900.

	VARIETIES	Pruned and Trained on Poles					Ordinary Field Culture				
		Date First Picking	Date Last Picking	No. of Fruits	Average Weight of Fruits, oz.	Per Acre, tons	Date First Picking	Date Last Picking	No. of Fruits	Average Weight of Fruit, oz.	Per Acre, tons
1	Prizetaker.	8/16	9/21	9	5.6	1.7	8/16	9/7	13	4.4	1.9
2	Acme	8/16	9/7	11	5.8	2.1	8/31	9/7	6	4.3	.8
3	New Queen	8/16	9/21	12	4.2	1.7	8/16	9/21	11	3.7	1.3
4	Stone	8/16	9/7	12	5.3	2.2	8/31	9/21	18	4.2	2.5
5	Beauty	9/7	9/7	2	2.5	.2	8/16	9/21	11	3.7	1.3
6	Buckeye State	8/31	9/7	3	11.0	1.1	8/31	9/7	3	5.0	.5
7	Paragon.	8/16	9/21	9	5.8	1.8	8/16	9/7	11	5.3	2.0
8	Perfection.	8/16	9/21	10	5.2	1.7	8/16	9/7	19	3.6	2.3
9	Ponderosa	8/16	8/31	3	3.3	.3	8/23	9/21	8	5.0	1.3
10	New Favorite	8/16	9/7	7	5.2	1.2	8/7	9/21	4	4.0	.5
11	Truckers' Favorite	8/23	9/21	5	9.4	1.5	8/23	9/7	11	5.5	2.0
12	Ignotum	8/16	8/31	4	6.5	.8	8/16	8/31	7	4.7	1.1
13	Climax	8/16	8/21	12	4.5	1.8	8/16	9/7	15	3.7	1.9
14	Ex. Ey. Purple Advance	8/23	8/21	25	1.4	1.2	8/23	9/21	19	3.1	2.0
15	White's Excelsior	9/7	8/21	2	6.5	.4	......	......	......	......	......
16	Long-Keeper	8/23	8/21	7	4.0	.9	8/31	9/21	2	6.5	.4
17	Enormous.	......	......	......	......	......	8/31	9/7	2	8.5	.5
18	Matchless	8/16	9/7	5	6.6	1.1	8/23	9/7	1	11.0	.3
19	Crimson Cushion	8/31	8/31	4	8.7	1.2	8/7	9/7	2	5.0	.3
20	Freedom	8/16	9/21	7	4.7	1.1	8/23	9/7	14	4.0	1.9
21	Imperial.	8/16	9/7	9	5.3	1.6	8/16	9/7	2	4.0	.3
	Averages	......	......	8	4.9	1.3	......	......	8.8	4.2	1.2

The following season the same experiment was tried, using only one variety, Sparks' Earliana. The plants on poles were set only one foot apart in the row and four feet between rows. Table V shows that the trained plants gave an increase of sixteen tons over plants of the same variety set 2½x4 ft. and allowed to run over the ground.

TABLE V.—METHODS OF CULTURE AND TRAINING TOMATOES. SHOWS RESULTS WITH SPARKS' EARLIANA TRAINED ON POLES VS. ORDINARY FIELD CULTURE.

	Per Acre Tons	Per Plant Lbs.	Per Plant Oz.
Trained on poles, 1 foot apart, 4 feet between rows, 10,890 plants	30.2	5	9
Ordinary field culture, 2½ feet apart, 4 feet between rows, 4,356 plants	14.2	6	7

A comparison of these tables will show that the increased yields come not so much from the difference in the manner of growth as from the larger number of plants it is possible to set upon an acre when the vines are tied to stakes. Under some special conditions favorable to the production of early crops, where an abundance of small undergrowth suitable for stakes could be readily secured in the woods, this pole method could be made very profitable. In private gardens, too, where land is valuable and limited in amount and where a neat appearance is desired, this method could be recommended.

VARIETY TESTS.

Novelties are constantly making their appearance and disappear as quickly, if not adapted to the needs of the grower. It would seem advisable, then, to publish the results of the variety tests annually in order that the value of these novelties might be quickly known. Such a plan, however, is open to criticism, because the growing of a variety for only one year is not sufficient to determine conclusively the merit of a new variety. The fact, too, that the great range of conditions found in the State has an important bearing upon the success or failure of a variety, makes it apparent that the Station might devote its energies to other lines of investigation with more valuable results. Much interesting information, however, may be derived from the running of variety tests over a series of years. In the work at this Station it can be seen that the new varieties are usually great yielders. In many cases after a few years they apparently run out and are replaced by others. These new varieties are often not much different from those which have gone before, but they usually run very high in yield for the first few years. As an illustration "Ignotum" was introduced in the season of 1890, and that year produced in our tests at the rate of 19 tons, 81 lbs, per acre. This was a new variety, which had been selected by Professor Bailey, in 1887, from a German strain. In 1899 it had dropped to fourth place in point of yield and at present is little known. In 1904 the tomato "Five Million Dollars," introduced by Salzer, gave the largest yield of tomatoes of its type. The following season it was still in the lead, but it dropped to nearly half its former yield in 1906, while the "Greater Baltimore," a new variety of similar character, had taken the lead with a yield of nearly 25 tons per acre.

These results can be accounted for, in some cases at least, by the fact that the stock passes from the hands of the originator and is allowed to revert and thus loses its value as a large yielder. The variety work thus shows how important it is to "rogue" and to "select" so as to keep the stock up to the ideal set by the originator.

Tables VI-XI give the yields of all the varieties tested here since 1900 with the exception of the season of 1902, when complete records were not secured. In these tests the seed was sown in the hotbed about March 1, and the plants transplanted four inches apart in cold frames, the first week in April. They were set out in the field with a block of earth attached about the 10th of May. No spraying was done in these tests because it was thought advisable to give only ordinary farm conditions.

At the bottom of Table XI will be found a record of the yields of five varieties considered suitable for canning. These were given about the same culture as would be given the canning tomato crop by the average grower. The seed was sown in a sheltered location in April. The plants were simply pulled from the bed and set in the field in hills on soil similar to that of the early crop and under like conditions. This experiment will be continued as it has frequently been noticed that the plants sown earlier and transplanted into cold frames and again into the field with a ball of earth attached give much larger yields than plants from seed sown a month later and set directly into the field. A final report upon this matter may suggest better methods of growing plants for the ordinary grower.

TABLE VI.—COMPARISON OF THE VARIETIES OF TOMATOES TESTED IN 1900. SIZE OF PLOTS 100 SQ. FT.

	VARIETIES	Date of First Picking	Date of Last Picking	Number of Fruits	Yield Per Plot		Average Weight	Yield Per Acre
					Lbs.	Oz.	Oz.	Tons
1	Beauty	7/13	9/4	199	44	7	3.5	9.5
2	New Queen	7/13	9/4	221	49	5	3.5	10.7
3	Royal Red	7/13	9/4	304	65	1	3.4	14.1
4	New Century	7/21	9/4	219	49	......	3.5	10.6
5	Maule's 1900	7/21	9/4	198	44	3	3.5	9.6
6	Matchless.	7/21	9/4	289	57	......	3.1	12.4
7	Combination	7/21	9/4	270	46	......	3.8	10.0
8	Ennobled	7/21	9/4	237	55	14	3.7	12.1
9	Kansas Standard	7/21	9/4	158	32	10	3.3	7.1
10	J. E. Swift	7/21	9/4	176	38	1	3.4	8.2
11	Salzer's 1900	7/21	9/4	268	49	......	2.9	10.6
12	Quicksure	7/21	9/4	77	20	......	4.1	4,3
13	Spark's Earliana	7/21	9/4	96	16	1	2.6	3.4
14	Quarter Century	7/21	9/4	120	26	3	3.4	5.7
15	Magnus.	7/21	9/4	176	32	8	2.9	6.9
16	Prizetaker	7/21	9/4	190	37	......	3.1	8.0
17	World's Fair	7/21	9/4	227	34	3	2.4	7.4
	Aver. for all varieties	......	......	190	38	6	3.3	8.6

TABLE VII.—COMPARISON OF THE VARIETIES OF TOMATOES TESTED IN 1901
SIZE OF PLOTS 100 SQ. FT.

	VARIETIES	Date of First Picking	Date of Last Picking	Number of Fruits	Yield Per Plot		Average Weight	Yield Per Acre
					Lbs.	Oz.	Oz.	Tons
1	New Imperial	7/10	8/20	136	32	6	3.8	7.0
2	Beauty	7/24	8/20	92	28	2	4.8	6.3
3	Acme	7/10	8/20	133	28	......	3.3	6.1
4	Fordhook First	7/10	8/20	103	26	4	4.0	5.7
5	Success	7/24	8/20	76	28	11	6.0	6.2
6	Burpee's Noble	7/10	8/20	62	18	7	4.7	4.0
7	World's Fair	7/10	8/20	66	21	11	5.2	4.7
8	Paragon	7/27	8/20	99	28	6	4.5	6.3
9	Stone	7/27	8/20	64	23	12	5.7	5.1
10	Enormous	7/10	8/20	9	3	7	6.1	.7
11	Magnus	7/10	8/20	57	20	3	8.4	4.3
12	Fordhook Fancy	7/10	8/20	44	8	9	3.0	1.8
13	Qnarter Century	7/10	8/20	69	14	1	3.2	3.0
	Aver. for all varieties	......	......	77	21	11	4.8	4.7

TABLE VIII.—COMPARISON OF THE VARIETIES OF TOMATOES TESTED IN 1903.
SIZE OF PLOTS 100 SQ. FT.

	VARIETIES	Date of First Picking	Date of Last Picking	Number of Fruits	Yield Per Plot		Average Weight	Yield Per Acre
					Lbs.	Oz.	Oz.	Tons
1	Favorite	7/18	9/15	160	41	4	4.1	8.9
2	Matchless	7/18	9/2	100	29	13	4.7	6.4
3	Enormous	7/18	9/2	17	8	8	8.0	1.8
4	Paragon	7/18	9/15	120	35	3	4.6	7.6
5	Success	7/18	9/15	110	34	15	5.0	7.6
6	Beauty	7/18	9/2	126	34	8	5.0	7.5
7	Acme	7/18	9/2	223	50	5	3.6	10.9
8	Freedom	7/18	9/15	289	55	13	3.0	12.1
9	Chalk's Early Jewel	7/18	9/2	183	49	9	4.3	10.7
10	Landreth Early	7/18	9/2	189	48	3	4.0	10.4
11	Nolte's Earliest	7/18	8/15	194	46	4	3.8	10.0
12	Spark's Earliana	7/18	8/22	173	38	10	3.5	8.4
13	New, for trial	7/18	9/15	65	22	15	5.6	4.9
14	Ponderosa	7/18	9/2	90	31	12	5.6	6.9
15	Stone	7/18	9/15	50	16	4	5.2	3.5
16	Imperial	7/18	9/2	97	31	7	5.1	6.8
17	Washington	7/18	9/2	120	30	12	4.1	6.6
18	Dwarf Champion	7/18	9/2	151	36	10	3.8	7.9
19	Rawson's Puritan	7/18	9/15	158	44	......	4.4	9.5
	Aver. for all varieties	......	......	137	36	2	4.6	7.6

TABLE IX.—COMPARISON OF THE VARIETIES OF TOMATOES TESTED IN 1904.
SIZE OF PLOTS 100 SQ. FT.

	VARIETIES	Date of First Picking	Date of Last Picking	Number of Fruits	Yield Per Plot		Average Weight	Yield Per Acre
					Lbs.	Oz.	Oz.	Tons
1	Beauty	7/16	8/29	234	120	14	8.2	26.7
2	Acme	7/9	8/29	379	99	......	4.1	21.5
3	Chalk's Early Jewel	7/5	8/29	302	99	11	5.2	21.7
4	Success	7/16	8/29	257	102	4	6.3	22.2
5	Sparks' Earliana	7/5	8/20	337	82	5	3.9	17.9
6	Five Million Dollar	7/16	8/29	333	118	3	5.6	25.7
7	Nolte's Earliest	7/5	8/24	357	115	......	5.1	25.0
8	Dwarf Stone	7/23	8/29	229	81	7	5.6	17.7
9	Vaughan's Model	7/16	8/29	225	56	6	4.0	12.2
10	Michel's Very First	7/9	8/20	202	53	2	4.2	11.5
11	Freedom	7/16	8/29	570	117	1	1.5	25.4
12	Magnificent	7/16	8/29	233	88	......	6.0	19.1
13	Rawson's Puritan	7/16	8/29	232	79	2	5.4	17.2
14	Tall Champion	7/16	8/29	253	84	12	5.3	18.4
	Aver. for all varieties	......	......	296	93	5	5.0	19.4

TABLE X.—COMPARISON OF THE VARIETIES OF TOMATOES TESTED IN 1905.
SIZE OF PLOTS 100 SQ. FT.

	VARIETIES	Date of First Picking	Date of Last Picking	Number of Fruits	Yield Per Plot		Average Weight	Yield Per Acre
					Lbs.	Oz.	Oz.	Tons
1	Globe......................	7/8	8/14	97	56	14	9.0	12.3
2	Truckers' Favorite	7/8	8/14	256	101	1	6.3	21.9
3	Santa Rosa................	7/8	8/14	177	112	5	10.1	24.4
4	Early Hustler	6/29	8/14	278	71	13	4.1	15.6
5	Paragon...................	7/14	8/14	247	102	4	6.6	22.2
6	New Magnificent	7/14	8/14	267	101	15	6.1	22.1
7	Acme	7/8	8/14	411	97	13	3.7	21.3
8	Five Million Dollar	7/14	8/14	356	116	5	5.2	25.2
9	Maule's Earliest...........	6/29	8/14	294	75	3	4.0	16.3
10	Tenderloin.................	6/29	8/14	323	130	......	6.4	28.2
11	Logan's Giant	7/8	8/14	160	82	12	8.2	18.0
12	Success....................	7/8	8/14	224	73	8	5.2	16.0
13	Chalk's Early Jewel	7/8	8/14	293	95	15	5.2	20.8
14	Liv. Beauty	7/8	8/14	399	107	14	4.3	23.4
15	Sparks' Earliana	6/29	8/14	203	72	11	5.7	15.8
16	Dwarf Stone	7/8	8/14	161	49	11	4.9	10.8
17	Buckeye State.............	7/14	8/14	177	81	13	7.4	17.8
18	Matchless	7/14	8/14	257	150	2	9.3	32.6
19	Stone	7/14	8/14	244	95	1	6.2	20.7
	Aver. for all varieties...	......	......	254	93	1	5.9	19.4

TABLE XI.—COMPARISON OF THE VARIETIES OF TOMATOES TESTED IN 1906. SIZE OF PLOTS 100 SQ. FT.

	VARIETIES	Date of First Picking	Date of Last Picking	Number of Fruits	Yield Per Plot		Average Weight	Yield Per Acre
					Lbs.	Oz.	Oz.	Tons
1	Greater Baltimore.........	7/21	9/14	411	111	15	3.1	24.3
2	Stone....................	7/21	9/14	213	81	5	6.1	17.6
3	Chalk's Early Jewel.......	7/14	9/4	221	76	......	5.5	16.5
4	Livingston's Globe.........	7/14	9/14	197	65	7	5.0	14.2
5	Salzer's Bountiful	8/4	9/14	213	69	......	5.1	15.0
6	Success..................	7/21	9/4	192	67	5	5.3	14.6
7	Truckers' Favorite	8/4	9/14	219	81	6	5.9	17.7
8	Matchless	7/21	9/14	164	49	4	4.8	10.7
9	Five Million Dollar	7/14	9/7	183	59	10	5.2	12.9
10	Sparks' Earliana	7/21	8/18	227	56	8	3.9	12.5
11	Wood's Improved Ponderosa	7/21	9/7	100	55	5	8.8	12.0
12	Beauty	7/28	9/7	202	83	8	6.6	18.1
13	Acme......................	7/21	9/7	237	60	12	4.1	12.7
14	Burpee's Earliest Pink	7/7	9/7	138	39	12	4.6	8.6
	Late Planted							
15	Success....................	8/11	9/14	84	27	12	5.2	6.0
16	Five Million Dollar	8/11	9/14	90	24	......	4.2	5.2
17	Paragon..................	8/15	9/7	55	20	12	6.0	4.5
18	Matchless	8/11	9/14	84	30	......	5.7	6.5
19	Stone.....................	8/11	9/14	63	21	2	5.3	4.5

Table XII gives the number of fruits and their weight in pounds and ounces for the pickings up to and including that of August 4, of fourteen varieties grown in the season of 1906. This gives a good idea of the comparative desirability of these varieties for early markets. Burpee's Earliest Pink would seem to be the most desirable in point of yield, with Sparks' Earliana next, and the others in their order.

TABLE XII.—COMPARISON OF EARLY TOMATOES, 1906. PICKINGS TO AUG. 4. SIZE OF PLOTS 100 SQ. FT.

VARIETIES	Number of Fruits	Yield Per Plot Lbs.	Yield Per Plot Oz.	Yield Per Acre Tons
Burpee's Earliest Pink	85	25	13	5.6
Sparks' Earliana	60	21	6	4.6
Greater Baltimore	57	19	3	4.1
Chalk's Early Jewel	50	16	6	3.5
Acme	35	10	..	2.1
Five Million Dollar	27	9	6	2.0
Success	16	6	12	1.4
Livingston's Globe	16	6	6	1.3
Matchless	16	6	2	1.3
Stone	16	5	14	1.2
Beauty	12	4	..	.8
Wood's Improved Ponderosa	5	2	10	.5
Truckers' Favorite	7	2	8	.5
Salzer's Bountiful	6	2	..	.4

AVERAGE COMPARATIVE YIELDS.

In Table XIII is given the yields of eighteen varieties of tomatoes for several years past. Some of these varieties have been tested for a period of eight years while others have been grown for a much shorter period. The last column gives a general average for the series of years, which indicates the comparative yields of the varieties.

TABLE XIII.—COMPARATIVE YIELDS OF TOMATOES PER ACRE.

	VARIETIES	1898 Tons	1899 Tons	1900 Tons	1901 Tons	1903 Tons	1904 Tons	1905 Tons	1906 Tons	General Average Tons
1	Five Million Dollar	....	....	....	....	....	25.7	25.3	12.9	19.2
2	Truckers' Favorite	....	6.6	....	....	....	....	21.9	17.7	16.0
3	Beauty	9.5	.7	9.5	6.3	7.5	26.7	23.4	18.1	15.1
4	Chalk's Ey. Jewel	....	....	....	....	10.7	21.7	20.8	16.5	14.9
5	Freedom	....	4.9	....	....	12.1	25.4	....	....	13.8
6	Acme	....	5.7	....	6.1	10.9	21.5	21.3	12.7	13.5
7	Stone	4.2	11.5	....	5.1	3.5	....	20.7	17.6	13.3
8	Matchless	8.9	7.3	12.4	....	6.4	....	32.6	10.7	12.1
9	Sparks' Earliana	....	....	3.4	....	8.4	17.9	15.8	12.5	11.9
10	Buckeye State	10.6	6.5	....	....	....	....	17.8	....	11.6
11	Royal Red	9.1	11.4	14.1	....	....	....	....	....	11.2
12	Paragon	9.6	5.3	....	6.3	7.6	....	22.2	....	10.2
13	Imperial	8.0	12.8	....	7.0	6.8	....	....	....	8.7
14	Favorite	11.3	4.7	....	....	10.1	....	....	....	8.7
15	World's Fair	8.6	....	7.4	4.7	....	....	....	....	6.9
16	Prizetaker	9.3	1.8	8.0	....	....	....	....	....	6.4
17	Enormous	....	4.5	....	.7	1.8	....	....	....	2.3

DESCRIPTION OF VARIETIES, 1906.

The Greater Baltimore is a handsome fruit of the same general type and color as the Stone, the so-called "red" or canning tomato. This seems to be a valuable addition to the list of varieties.

The Stone is too well known to need a description here.

Chalk's Early Jewel is a good variety for market or home use. It is fairly early and will yield larger crops and over a longer period than will Sparks' Earliana.

Livingston's Globe is a fine, meaty tomato. It is globe shaped and on this account is considered desirable for slicing for the table.

Salzer's Bountiful is a new and prolific variety, but is poor in color, being a yellowish red.

Success is of the same general type as Stone, Paragon, etc.

Truckers' Favorite is a purple tomato suitable for market although usually a little more irregular in shape than the Beauty.

Matchless is an old standard variety suitable for market or canning purposes.

The Five Million Dollar is of the same type as the Stone and has given heavy yields in the two years just past.

Sparks' Earliana is one of the earliest of the smooth, regular tomatoes, but it needs rich soil and close planting in order to get large crops for market or home use.

Wood's Improved Ponderosa is very much like the old Ponderosa with large fruits.

Livingston's Beauty is the old standard purple variety and is an excellent market sort where this color is in demand.

The Acme is similar to Beauty, but is earlier and not quite so large.

Burpee's Earliest Pink is similar to Acme or Beauty in color but is very early. It is too rough for a good market sort.

INTERESTING ITEMS ABSTRACTED FROM SUMMARIES OF PREVIOUS BULLETINS ON TOMATOES OF THE MARYLAND AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 11, DECEMBER, 1890.

Range of yield, 2 to 20 tons per acre, General average 11¾ tons. Selected varieties average 14 tons.

The best yielder was the "Ignotum," 19.81 tons per acre.

The greater the number of cells in the tomato the higher the percentage of solid flesh. An average of 10¾ cells per fruit gives 80 per cent. of flesh.

Pot-grown plants undisturbed from the seed do not damp off as easily as plants bed-grown and transplanted.

Pot-grown plants exceed transplanted plants in product 18 per cent. or at rate of two tons per acre.

In earliness or first months of bearing pot-grown plants yield double the others. For quantity of crop tomatoes should be well manured but it is not well to grow them on the same land successive years.

Better results generally followed the use of two fertilizing elements combined than one used alone, but potash alone gave good results, better than some mixtures.

Phosphoric acid alone had little effect on quantity of crop.

Nitrate of soda and muriate of potash can be recommended as special fertilizers for the tomato.

Potash fertilizers seem to decrease sugar and increase acid in tomatoes.

Phosphoric acid plots produced some of the sweetest tomatoes found.

Nitrogen and potash affect composition of fruit more than phosphoric acid.

The tomato is not a specially exhausting crop. Tomatoes do not remove as much plant food from soils as most farm crops at the usual rates of product per acre.

The refuse of the crop from an acre of tomatoes contains more fertilizing material than similar remains of most other crops.

The vines and roots of tomatoes are very rich in potash.

The residue of the tomato crop should be evenly spread and plowed under.

As regards economy of soil fertility the tomato crop is a desirable one to raise.

BULLETIN NO. 25, MARCH, 1894.

Healthfulness of stock from which to propagate is of the first consideration. Some varieties of tomatoes seem more susceptible to disease than others. Vigor of plant, productiveness, and quality of fruit should determine selection.

Judicious shipment in advance of local competition offers the largest promise of profit.

The economic use of commercial fertilizers is dependent on other supplemental conditions as well as the facts of the available plant food contained in them.

BULLETIN NO. 54, MARCH, 1898.

The best varieties for main crop trucking are Paragon, Prize Taker, Perfection, World's Fair and Climax.

The best varieties for the canning trade are Royal Red, Queen, Stone, Paragon, and Matchless.

The best variety for late market or family use is the Buckeye State.

The use of the Bordeaux solution proved an effectual means of holding the tomato leaf blight in check.

In 1896 spraying with Bordeaux solution four times produced, with 35 varieties, an average increase in yield of 2.5 tons per acre of marketable fruit.

In 1897 spraying with Bordeaux solution three times produced, with 19 varieties, an average increase in yield of 2.2 tons per acre of marketable fruit.

Some varieties are more susceptible to the blight than others. In 1896 all but one variety, and in 1897 all but three varieties gave an increased crop of ripe fruit as a result of spraying with Bordeaux solution, and all of the varieties showed an increase when the amount of green tomatoes at the end of the season was added.

The increase in crop as a result of spraying, ranged from ¼ of a ton to 6 tons in 1896, and from ¼ to 4¼ tons in 1897.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 114. JANUARY, 1907.

FERTILIZER EXPERIMENTS WITH DIFFERENT SOURCES OF PHOSPHORIC ACID.

By H. J. Patterson.

The experiments reported upon in this bulletin were inaugurated in 1895. A report of progress on the tests was made in Bulletin No. 68, published in September, 1900. The object of the experiment was to test the availability of different sources and forms of phosphorous and methods of rendering insoluble phosphates available in the soil.

PLAN OF THE EXPERIMENTS CONDUCTED.

The general plan of the experiments consisted in the testing of the availability of different forms of phosphoric acid and means for rendering insoluble phosphates available in the soil. The idea in mind was to make these tests much more than a soil test of a particular farm, and they were so planned and conducted as to make the results applicable to most parts of this State, and of general interest to agriculture wherever commercial fertilizers are used.

The idea that pervaded the plan was to imitate nature and get the land as nearly as possible in the same condition it was when a virgin soil and then continue to use nature's methods for maintaining fertility.

It is well known from chemical analysis of soils that they contain sufficient phosphoric acid to furnish all that is needed for good crops for many years. It has also been shown that some soils which fail to produce satisfactory crops contain more phosphoric acid than those that are considered fertile. Now this difference in fertility must be due to a condition of availability.

An examination of the conditions which prevailed in virgin soils, or in any soil that has just been cleared of its forest growth, soon makes prominent the fact that nature has filled that soil with organic matter, this organic matter not only gives the soil a dark color and fine physical appearance but it also performs functions in producing chemical changes that cannot take place in that same soil were it destitute of organic matter. Again we find that a virgin soil will produce satisfactory crops for a number of years without the intervention of commercial fertilizers; but about as soon as the organic matter has been worked out, the soil fails to produce satisfactory crops, and the use of phosphates is resorted to.

Now the phosphorous which these soils contained was not in a form soluble in water, nor was it in the form of reverted or dicalcium phosphates, but was an insoluble phosphate of lime, magnesia, iron or alumina. Though termed insoluble, yet this phosphoric acid was available to crops, through the chemical changes made possible by the presence of organic matter and the compounds formed through its decomposition. It was the water charged with carbonic, humic and other organic acids, formed by the decomposition of vegetable matter, that was able to dissolve the insoluble phosphates of the virgin soils and place them either directly at the disposal of crops, or form such combinations as could be utilized thereafter.

As soon as the organic matter of the soil was consumed these favorable conditions no longer obtained, and crops could not avail of the natural properties of the soil even though there was an abundance there. Now if nature's methods are observed again, it will be noticed that wherever she is producing vegetation she has devised means for depositing some vegetable matter in the soil.

Taking all these facts into consideration would it not seem reasonable that, in order to avail properly of the phosphates contained naturally in the soil, that it would be necessary to imitate nature's methods and fill the soil with organic matter. Then again could not the phosphoric acid contained in the mineral phosphates be rendered available in the soil through the agency of organic matter if these phosphates were applied in their original chemical condition, but pulverized? If these questions can be answered in the affirmative, and the farmer can arrive at an economical and satisfactory method of providing the requisite amount of organic matter in the soil, then it will be possible to avail of the phosphates already in the soil; and thus, on some lands, make it unnecessary to purchase phosphoric acid. When recourse to purchase becomes necessary, then a cheaper form can be used and do away with paying out so much money for dissolved or acid treated phosphates, which in the end seems largely a means of accomplishing or arriving at a mechanical condition; that is, of getting the phosphates precipitated in the soil in a finely divided state and forming thin coatings over the particles of soil.

These are the ideas that called for the planning and management of the experiments outlined in the following program:

TABLE I.

Phosphoric Acid Experiments.

(Plots one-tenth of an acre each.)

Plot No.	Kind of Fertilizer and Treatment.	Quantity* Per Plot.	Quantity Per Acre.
	Crimson Clover Seeded in Corn.	*Lbs.*	*Lbs.*
1	Double Super-Phosphates (Soluble P_2O_5)	32	319
2	Dissolved Bone black (Soluble P_2O_5)	73½	735
3	Dissolved South Carolina rock (Soluble P_2O_5)	100	1000
4	Double Super-Phosphates (Reverted P_2O_5)	37	370
5	Nothing	......	......
6	Iron Alumina Phosphate (Reverted P_2O_5)	37	370
7	Bone black (Insoluble P_2O_5)	51½	514
8	Raw bone meal (Insoluble P_2O_5	66¾	667
9	Slag Phosphate Insoluble P_2O_5)	92	920
10	Nothing	......	......
11	Ground South Carolina rock (Insoluble P_2O_5)	53	530
12	Florida Soft Phosphate (Insoluble P_2O_5)	56	560
	Corn-ground left bare during winter, no green crop turned under.		
13	Same as No. 8	66¾	667
14	Same as No. 9	92	920
15	Nothing	......	......
16	Same as No. 11	53	530
17	Same as No. 12	56	560
	Rye seeded in Corn Stubble and turned under for next crop.		
18	Same as No. 8	66¾	667
19	Same as No. 9	92	920
20	Nothing	......	......
21	Same as No. 11	53	530
22	Same as No. 12	56	560

*These quantities give each plot the same quantity of phosphoric acid, (150 pounds per acre, which was determined by analyzing the materials used.)

The piece of land used for these experiments lies north of the Experiment Station buildings and along the fence west of the pike. This land is a moderately stiff clay, naturally quite well drained though fairly level. The general character of the plots is quite uniform, in fact more so than most pieces of like area in this formation.

The history of the cropping of the land used for this test was, so far as known, as follows: in 1888 there was a poor stand of grass and weeds on this land, which was plowed down and seeded to wheat, which was harvested in 1889; grass 1890-91; corn 1892; fallowed 1893, and in wheat 1894—clover and timothy seeded in wheat and gave a good set.

Plots were numbered, commencing at end next Experiment Station building, toward Paint Branch.

DESCRIPTION OF PHOSPHATES USED IN THE EXPERIMENTS.

A detailed description of all the materials mentioned in Table 13 can be found in Bulletin No. 6 of this Station, so that a description of only those used in the test outlined in Table 1 will be given here. These will be described in the order of the plot numbers.

The materials used were selected so as to give all the forms of phosphoric acid found in fertilizers and to have them furnished by the chief sources of phosphoric acid on the market at the time the experiment was inaugurated.

PLOT NO. 1.—DOUBLE SUPERPHOSPHATE.

This, as its name indicates, is a concentrated form of soluble phosphoric acid. It is made by dissolving mineral phosphates in phosphoric acid instead of sulphuric acid. The process of manufacture consists of treating a low grade of phosphate rock, or those too poor in phosphoric acid to make a high grade or standard superphosphate, with an excess of dilute sulphuric acid. This sets free the phosphoric acid, which, together with the excess of sulphuric acid, is removed and separated from the insoluble materials by filtration and washing. The acid solutions thus obtained are concentrated and then used for dissolving the better class of phosphate rock. Because the acids used for dissolving the phosphates contain phosphoric acid, the product yielded contains more than double the amount of phosphoric acid in the ordinary product.

Double superphosphate is manufactured, to some extent, in this country, but mostly in Europe. Its use in this country is not as great now as it was a few years ago. This was selected as one of the sources of phosphoric acid, as it contains a minimum of impurities and a maximum of phosphoric acid in the soluble form.

DISSOLVED BONE-BLACK (PLOT 2) AND BONE-BLACK (PLOT 7.)

When broken bones are placed in a retort or iron cylinder, the air being excluded, and then strongly heated, gas, water, oily matters and other products are driven off, while black-bone charcoal is left. This product, also known as bone-black and animal charcoal, is used extensively in sugar refineries for taking the coloring matter out of raw sugars. From time to time portions of the bone charcoal cease to be effective in clarifying and the spent black is then sold by the refineries for fertilizing purposes. All the phosphoric acid originally in the bones is retained, but the presence of carbon prevents the phosphate from decomposing. It is as "dissolved bone-black" that this article is generally found on the market. Dissolved bone-black contains a large proportion of soluble phosphoric acid and a very small amount in the insoluble form. Dissolved bone-black was applied on Plot No. 2, and the untreated bone-black on Plot No. 7.

DISSOLVED S. C. ROCK, PLOT NO. 3.

This constitutes by far the greater bulk of the materials now used in this country for making phosphate manures. An immense trade has grown up in this class of phosphates during the last thirty years. The most common name by which this class is known is "Acid Phosphates," but it is also found on the market as Dissolved S. C. rock, Dissolved S. C. bone, and Bone Phosphate rock. While the rock which was first used for making this class of fertilizers was first found in South Carolina, yet much of it now comes from deposits in Florida and Tennessee. The dissolved phosphates of this class contain a large portion of their phosphoric acid in the available condition, but not quite as much in the soluble form as in dissolved bone-black.

PLOT NO. 4—REVERTED PHOSPHATE OF LIME.

The phosphate applied on this plot had for its base some of the same double superphosphate used on Plot No. 1, with which had been mixed, before application, sufficient lime to change the phosphoric acid from the soluble to the reverted state. This was used in the hopes of procuring some data from the crops as to the relative availability of phosphoric acid in the soluble and reverted form.

PLOT NO. 6—REVERTED PHOSPHATE OF IRON AND ALUMINA.

This plot was added so as to give an opportunity for comparing fertilizers which contained the phosphoric acid largely in combination with lime (Plot 4) with those that had it principally in combination with iron and alumina. The material applied to this plot was what is known on the market as "Keystone Concentrated Phosphate," and was being extensively manufactured and sold about the time these tests were planned, but has gone almost, if not entirely, out of the market now.

PLOT NO. 7—BONE-BLACK.

Insoluble phosphoric acid. Description given under Plot No. 2.

PLOT NO. 8—RAW BONE, GROUND BONE AND BONE MEAL.

Animal bones are composed of two distinct substances, which interpenetrate one another. There is a sort of frame-work of earthy matter, which is phosphate of lime or bone phosphate, and a fleshy filling called ossein, which is a substance containing much nitrogen. Raw bones, are, therefore, doubly valuable for manurial purposes, because they contain both phosphoric acid and nitrogen. As ordinarily collected, bones contain from 50 to 60 per cent. of phosphate of lime and from 5 to 7 per cent. of nitrogen. Fresh raw bones also contain fat, and this is not only useless as a plant food but it adds weight to the bone and makes it hard to grind; and when ground, the more fat remaining in the bone, the slower will be the decomposition in the soil. To obviate this difficulty bones are generally steamed, or carried through some process to remove fat, before they are ground for fertilizers. Steamed or dessicated bones, if not too strongly steamed, are better for fertilizer than raw bones. Some nitrogen is lost by these processes, but if carefully done, the gain exceeds the loss. Bone-meal is obtained by grinding the crude or steamed bones, and it is valuable in proportion to the degree of fineness to which it is reduced. According to its fineness, it is variously called ground-bone, bone-meal, flour-of-bone, and bone-dust. The finer it is, if used without acid, the easier it decays or dissolves in the soil and the sooner the process of nature converts the (tri-calcic) phosphate of lime to a form available for plants. Good ground bone or bone-meal should contain from 20 to 25 per cent. of phosphoric acid and from 3 to 4 per cent. of nitrogen.

The demand for bones for use in various arts and especially in refining sugar, is making this form of fertilizing material comparatively scarce in the market and correspondingly high in price. If rates advance much it will become unprofitable for farmers to use bone fertilizers for their phosphates. The same causes lead to the considerable adulteration of bone-meal that is now found. Lime, gypsum, coal ashes, ground oyster shells, crab shells, and like articles are used for this purpose as well as the less objectionable mixing of fine ground rock phosphate, all being sold under the name of bone. When bone, ground bone, or bone-meal is treated with sulphuric acid, the product is the dissolved bone of our markets, also known as acidulated bone, soluble bone and dissolved bone phosphate. This is simply an acid phosphate or superphosphate, made from bones.

PLOT NO. 9—SLAG PHOSPHATE, BASIC IRON SLAG, OR THOMAS SLAG MEAL.

To these names may be added Thomas Scoria and Odorless Phosphate, all given to a waste material or slag, which is a by-product in the preparation of steel, by what is known as the "basic process." The object of this process is the extraction of phosphorous from pig iron, by means of a basic lining of the converter invented by Jacob Reese. The product of the process is a substance containing from 15 to 20 per cent. of phosphoric acid. It is metallic in appearance but may be ground very fine forming a dark brown meal. The phosphoric acid is in combination chiefly with lime, as tetra-calcium phosphate;

it is insoluble in water, slightly soluble in ammonium citrate, and is by ordinary methods of analysis, classified largely as insoluble. Yet its condition is such that soil water, when charged with carbonic acid, will dissolve it to a considerable degree. Thomas Slag is largely used and highly valued in Germany, and is the cheapest form in which phosphoric acid can be obtained by the farmers of that country. Eminent German experimenters have lately spoken strongly in its favor. Wagner states that two pounds of this material, ground fine, (with no acid treatment), containing 18 per cent. phosphoric acid and without any other valuable plant food, costing 4½ cents, produced the first year after its use, the same increases in yield as one pound of soluble phosphoric acid from bone-meal costing 6½ cents. And in the second year the effect of the Thomas Slag was twice that of the other. These are important facts, but the place of this slag phosphate among the commercial phosphates of this country has yet to be determined.

This material gets the name by which it is best known in Europe from S. G. Thomas, of England, who claimed to be the prior inventor of the basic process of making pure steel. This claim was disputed by Jacob Reese, of Pennsylvania, and the courts of this country have confirmed the claim of Reese. The slag is now manufactured by the latter and is sold under the name of Odorless Phosphate. This is the slag very finely pulverized but not treated with acid.

PLOT NO. II—GROUND SOUTH CAROLINA ROCK, (INSOLUBLE PHOSPHORIC ACID.)

The material applied to this plot is the natural phosphate finely ground and just in the same condition in which the manufacturers put it before treating with acid. The phosphoric acid is chiefly in the state of the tri-calcium phosphate. If this ground rock could be successfully used so as to give satisfactory crops, the cost of a pound of phosphoric acid would be reduced over one half. These mineral phosphates are chiefly obtained from immense natural deposits in North Carolina, Tennessee, Georgia, and Florida, and generally in the rivers and low lands along the coast. Bones and fossil teeth were dug up in a swamp near the Cooper river almost a hundred years ago, but a knowledge of the extent of the deposits and their economic value have been developed within forty years.

The most prominent characteristic of the native phosphate is its nodular form. Even where the deposits occur as an apparently smooth and compact layer, or in large flat cakes, it is nevertheless composed of irregular nodules, partially cemented together. Nearly all these nodules have the egg or kidney shape. The exterior is sometimes rough and indented, often honey-combed with round or irregular holes, and sometimes it is smooth and compact. The surface is occasionally shiney and coated as with enamel. Fossil shells, fish bones and teeth are not infrequently found embedded in the nodules, and other animal remains occur in the same general deposits. The nodules vary in size from the fraction of an inch to several feet in diameter, and in weight up to almost a ton. When found, as much of this deposit is, in river bottoms or under marsh-mud, the color of the material is a grey or bluish-black. The land rock is usually of a lighter color, yellowish or greyish white. The masses are easily broken and ground to a fine powder, light yellow or grey, often becoming so light as to float in the air. In this extremely fine condition, and before being treated with acid, the material is often called Floats. There is no reasonable doubt that these phosphates came from the remains of both marine and land animals, although it would be out of place to give the evidence here. A long series of geological transformations is involved, together with different eras of animal life and subsequent changes in the mineral matters themselves. From several hundred analyses of the raw or simply ground Carolina rock, the mineral has been found to contain on an average from 25 to 28 per cent. of phosphoric acid, 2.5 to 5 per cent. of carbonic acid, 0.5 to 2 per cent. sulphuric acid, 35 to 42 per cent. lime, and a little magnesia, soda, silica, iron and other elements. The finding of the fossil bones, teeth, etc., spoken of, has led to the term "South Carolina bone" being incorrectly applied to these mineral phosphates.

PLOT NO. 12—FLORIDA SOFT PHOSPHATE; (INSOLUBLE PHOSPHORIC ACID.)

Florida soft phosphate is chiefly an alumina iron phosphate which occurs in large quantities deposited in many parts of that State. It is not well adapted to treatment with acid for making soluble phosphates, as the alumina and iron make a sticky mass which is hard to dry and keep in a good mechanical condition. The Florida soft rock has been largely used as a fertilizer in its natural condition in some parts of that State on the light, sandy land, giving good results. When used in this way there has been applied at the same time heavy dressings of the native mucks from the swamps and lakes. This muck furnishes nitrogen as well as the much needed organic matter. In order to have a complete fertilizer there is also applied some German potash salt.

The Florida soft phosphate was used in this test in order to compare the lime and alumina phosphates in the insoluble forms.

TABLE II.

Analysis of Phosphates Used on Phosphoric Acid Plots.

Index No.		Total Phosphoric Acid (P_2O_5) Per Cent.
1706	Double Super-Phosphate	47.04
1707	Dissolved bone-black	20.40
1708	Dissolved South Carolina rock	15.04
108	Reverted Iron and Alumina Phosphates	43.20
1709	Bone-black	29.20
1713	Raw bone-meal	22.48
1712	Slag Phosphate	16.32
1710	Ground South Carolina rock	28.32
1711	Florida soft Phosphate	26.80

SYNOPSIS OF TESTS UNDER CONSIDERATION.

1. Testing the principal sources of soluble phosphoric acid.
2. Comparing the availability of soluble, reverted and insoluble phosphoric acid.
3. Comparing phosphate of lime and phosphate of alumina and iron in the reverted forms.
4. Comparing the principal sources of insoluble phosphates, both in the lime, alumina and iron compounds.
5. Comparing the tri-calcium and tetra-calcium phosphates.
6. Testing the effect which green manures and the accumulated vegetable matter therefrom have, in aiding the availability of the insoluble phosphate.
7. Comparing a leguminous and a graminacious crop for the purpose of rendering insoluble phosphate available.

YIELDS OF PLOTS.

The treatment of the plots from time to time was uniform except as to the kind of phosphate applied and the use of the green manures. The details as to the yields of the crops from the various plots for the twelve years of the test are given in the following tables: 3, 4, 5, 6, and 7.

TABLE III.

Showing Yields of Corn (grain) from Phosphoric Acid Plots.

(Yields in bushels per acre.)

Plot No.	Kind of Fertilizer and Treatment.	1895	1896	1897	1902	1903	1906	Total 6 Crops.	Average of 6 Crops.
1	Soluble Phos. Acid from Double Super-Phosphate.	46.0	40.3	57.9	45.7	17.6	39.9	247.4	41.2
2	Soluble Phos. Acid from dis. bone black.	38.7	37.4	51.1	46.4	21.8	46.1	241.5	40.3
3	Soluble Phos. Acid from dis. rock..	39.0	35.8	43.6	43.6	16.2	44.6	222.8	37.1
4	Reverted Phosphate of lime.......	35.8	37.0	47.7	46.4	29.3	45.8	242.0	40.3
5	Nothing...........................	42.6	42.0	57.3	42.4	33.9	43.8	262.0	43.7
6	Reverted Phosphate of iron and alumina.	45.4	43.2	64.9	50.0	18.0	42.7	264.2	44.0
7	Insoluble Phosphate, bone black...	36.9	41.6	58.1	43.2	17.8	34.1	231.7	38.6
8	Insoluble Phosphate, raw bone....	37.8	43.0	61.9	45.4	12.4	23.6	224.1	37.4
9	Tetra-Phosphate, Slag Phosphate..	38.4	42.1	58.4	39.1	7.2	26.0	211.2	35.2
10	Nothing...........................	39.4	38.6	49.4	38.4	24.3	36.3	226.4	37.7
11	Insoluble Phosphate, S. C. rock...	42.4	44.8	60.7	38.3	9.3	37.7	233.2	38.9
12	Insoluble Phosphate, Florida soft rock.	44.0	46.3	63.1	46.4	35.9	44.7	280.4	46.7
13	Same as Plot 8....................	49.4	49.1	58.4	42.4	16.0	20.9	236.2	39.4
14	Same as Plot 9....................	43.4	44.4	46.6	41.6	16.0	26.7	218.7	36.5
15	Nothing...........................	41.4	44.1	41.1	34.3	38.8	43.3	243.0	40.5
16	Same as Plot 11..................	47.7	45.0	40.4	41.4	32.5	39.7	246.7	41.1
17	Same as Plot 12...................	48.2	42.4	34.4	42.5	39.6	36.8	243.9	40.7
18	Same as Plot 8....................	47.1	40.4	42.7	51.4	36.0	33.6	251.2	41.9
19	Same as Plot 9....................	49.3	45.3	44.6	51.3	44.7	39.0	274.2	45.7
20	Nothing...	50.0	43.0	37.0	35.7	44.1	41.6	251.4	41.9
21	Same as Plot 11...................	45.5	41.7	30.1	47.9	29.0	41.1	235.3	39.2
22	Same as Plot 12...................	47.9	33.4	36.4	51.1	30.7	42.0	241.5	40.2

TABLE IV.

Showing Yields of Corn Fodder from Phosphoric Acid Plots.

(Yields in pounds per acre.)

Plot No.	Kind of Fertilizer and Treatment.	1895	1896	1897	1902	1903*	1906	Total 5 Crops.	Average of 5 Crops.
1	Soluble Phos. Acid, Double Super-Phosphate.	2860	2100	3020	2600	750	2000	12580	2516
2	Soluble Phos. Acid, dis. bone black.	2700	2200	2930	2600	785	2300	12730	2546
3	Soluble Phos. Acid, dis. rock.....	2400	2340	2810	2650	*	2050	12250	2450
4	Reverted Phosphate of lime......	2420	2060	2920	2650	*	2150	12200	2400
5	Nothing........................	2580	2200	3190	2150	*	2100	12220	2440
6	Reverted Phosphate of iron and alumina.	2940	2400	3330	2950	*	2200	13820	2764
7	Insoluble Phosphate, bone black..	2340	2160	3070	2550	*	1700	11220	2244
8	Insoluble Phosphate, raw bone meal.	2100	2340	3320	2750	*	1200	11710	2342
9	Tetra-Phosphate, Slag Phosphate.	2100	2320	2670	2450	500	1300	10840	2168
10	Nothing........................	1980	2060	2460	2300	1050	1800	10600	2120
11	Insoluble Phosphate, S. C. rock..	2260	2360	3060	2250	800	1800	11730	2346
12	Insoluble Phosphate, Florida soft rock.	2180	2580	3190	2770	1750	2000	12720	2544
13	Same as Plot 8..................	2760	2680	3160	3300	1300	1500	13400	2680
14	Same as Plot 9..................	2120	2500	3130	3200	950	1400	12350	2470
15	Nothing.........................	2460	2360	2980	2650	2150	2050	12500	2500
16	Same as Plot 11.................	2620	2420	2880	3120	1750	2200	13240	2648
17	Same as Plot 12.................	2700	2140	3020	3330	2350	1800	12990	2598
18	Same as Plot 8..................	2520	2180	2660	3150	1500	1850	12360	2472
19	Same as Plot 9..................	2800	2320	2980	3350	1700	2200	13650	2730
20	Nothing..	2900	1900	2480	2300	2340	2400	11980	2396
21	Same as Plot 11.................	2460	1900	2820	2750	1850	2450	12380	2476
22	Same as Plot 12.................	2760	1200	2660	3400	1800	2350	12370	2475

*Corn fodder in 1903 from same plots was used on hallow'een for building a fence across the road and made it impossible to separate the plots for weighing. This year's records are omitted from totals and averages.

TABLE V.

Showing Yield of Wheat from Phosphoric Acid Plots.

(Yield of Grain in bushels and Straw in pounds per acre.)

Plot No.	Kind of Phosphate and Treatment.	GRAIN.			STRAW.		TOTALS.		
		1889 bu.	1904 bu.	Average bu.	1899 lbs.	1904 lbs.	Grain bu.	Straw lbs.	Grain and Straw lbs.
1	Soluble Phosphoric Acid, Double Super-Phosphate.	36.0	12.2	24.1	4140	1070	48.2	5210	8102
2	Soluble Phosphoric Acid, dissolved bone black.	37.1	12.0	24.6	4375	775	49.1	5150	8096
3	Soluble Phosphoric Acid, dissolved rock.	37.0	12.3	24.6	2930	760	49.3	3690	6648
4	Reverted Phosphate of lime.....	31.6	12.8	22.2	3550	1030	44.4	4580	7244
5	Nothing..........................	22.0	5.2	13.6	2580	440	27.2	3020	4652
6	Reverted Phosphate of iron and alumina.	34.6	12.2	23.4	3170	1070	46.8	4240	7048
7	Insoluble Phosphate, bone black.	25.6	9.3	17.5	3415	590	34.9	4005	6100
8	Insoluble Phosphate, raw bone meal.	34.5	11.8	23.2	4100	1090	46.3	5190	7968
9	Tetra-Phosphate, Slag Phosphate.	34.8	7.2	21.0	4160	470	42.0	4630	7150
10	Nothing..........................	20.7	1.5	11.1	2300	310	22.2	2610	3942
11	Insoluble Phosphate, South Carolina rock.	29.8	8.0	18.9	3710	720	37.8	4430	6698
12	Insoluble Phosphate, Florida soft rock.	30.8	6.3	18.6	3800	620	37.1	4420	6646
13	Same as Plot 8...................	35.5	10.2	22.9	3720	590	45.7	4310	7052
14	Same as Plot 9...................	37.6	6.2	21.9	4395	730	43.8	5125	7753
15	Nothing..........................	22.0	3.3	12.7	2180	200	25.3	2380	3898
16	Same as Plot 11..................	32.8	8.5	20.6	3530	890	41.3	4420	6898
17	Same as Plot 12..................	29.1	6.3	17.7	2800	320	35.4	3120	5244
18	Same as Plot 8...................	36.0	14.8	25.4	3890	1260	50.8	5150	8198
19	Same as Plot 9...................	36.1	14.6	25.4	4030	1125	50.7	5155	8197
20	Nothing..........................	22.6	2.3	12.5	3345	410	24.9	3755	5249
21	Same as Plot 11..................	31.9	9.7	20.8	3285	720	41.6	4005	6501
22	Same as Plot 12..................	30.1	16.5	23.3	2800	990	46.6	3790	6586

TABLE VI.

Showing Yield of Hay from Phosphoric Acid Plots.

(Yields in pounds per acre.)

Plot No.	Kind of Fertilizer and Treatment.	1900	1901	1905	Total Yield of 3 Crops.	Average Yield of 3 Crops.
	Corn-ground Seeded in Crimson Clover.					
1	Soluble Phosphoric Acid from double Super-phosphate.	3900	4300	2400	10600	3533
2	Soluble Phosphoric Acid from dissolved bone black.	4200	4310	2500	11010	3670
3	Soluble Phosphoric Acid from dissolved rock.	4950	4050	2400	11400	3800
4	Reverted Phosphate of lime..........	4250	4650	3400	12300	4100
5	Nothing..............................	4150	3450	1500	9100	3033
6	Reverted Phosphate of iron and alumina.	4800	6450	2900	14150	4717
7	Insoluble Phosphate of lime, bone black.	4000	4350	2700	11050	3683
8	Insoluble Phosphate of lime, raw bone meal.	4500	3800	2700	11000	3666
9	Tetra-phosphate, slag phosphate.......	2450	3800	2150	8400	2800
10	Nothing..............................	4000	3600	900	8500	2833
11	Insoluble Phosphate of lime, South Carolina rock.	4400	3950	2050	10400	3466
12	Insoluble Phosphate of iron and alumina, Florida soft rock.	4750	4600	2300	11650	3883
	Corn-ground bare during winter.					
13	Same as Plot 8........................	2800	4000	2500	9300	3100
14	Same as Plot 9........................	4900	4250	4650	13800	4600
15	Nothing..............................	3200	3450	550	7200	2400
16	Same as Plot 11......................	3700	5050	3200	11950	3983
17	Same as Plot 12......................	3950	4750	2650	11350	3783
	Corn-ground seed in rye					
18	Same as Plot 8...........	4300	4800	3850	12950	4317
19	Same as Plot 9........................	3300	5500	4100	12900	4300
20	Nothing..............................	4000	4750	1450	10200	3400
21	Same as Plot 11......................	4550	4600	3650	12800	4266
22	Same as Plot 12......................	3450	4200	3330	10980	3660

TABLE VII.

Showing Summary of Yields with Different Forms and Sources of Phosphoric Acid.

(Yields in bushels and pounds per acre.)

	Average of 6 Crops of Corn		Average of 2 Crops of Wheat		Average of 3 Crops of Hay	Total Average Yield of 11 Crops. Lbs.
	Grain bu.	Fodder lbs.	Grain bu.	Straw lbs.		
Average of 4 nothing plots (5, 10, 15, 20.)	40.9	2346	12.5	1470	2916	10345
Average of 3 Soluble Phosphoric Acid plots (1, 2, 3.)	39.5	2504	24.4	2342	3668	12743
Average of 2 Reverted Phosphoric Acid plots (4, 6.)	42.1	2582	22.8	2205	4409	13511
Average of 5 Insoluble Phosphoric Acid plots, crimson clover turned under (7, 8, 9, 11, 12.)	39.4	2329	19.8	2268	3500	12043
Average of 4 Insoluble Phosphoric Acid plots, crimson clover turned under (8, 9, 11, 12.)	39.6	2350	20.4	2259	3454	12059
Average of 4 Insoluble Phosphoric Acid plots, nothing turned under (13, 14, 16, 17.)	39.4	2599	20.8	2247	3866	12718
Average of 4 Insoluble Phosphoric Acid plots, rye turned under (18, 19, 21, 22.)	41.8	2538	23.7	2263	4211	13360
Average of 12 Insoluble Phosphoric Acid plots (8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22.)	40.2	2497	22.5	2256	3844	12761
Average of 3 Bone meal plots (8, 13, 18.)	39.6	2496	23.6	2442	3694	12820
Average of 3 Slag Phosphate plots (9, 14, 19.)	39.1	2440	22.6	2485	3900	12918
Average of 3 South Carolina rock plots (11, 16, 21.)	39.7	2490	20.1	2143	3905	12520
Average of 3 Florida soft phosphate plots (12, 17, 22.)	42.5	2539	19.9	1889	3775	12372
Comparison of						
Reverted Phosphate of lime, Plot 4.	40.3	2400	22.2	2290	4100	12943
Reverted Phosphate of iron and alumina, Plot 6.	44.0	2764	23.4	2120	4717	14085
Comparison of						
Bone black, Plot 7	38.6	2244	17.5	2002	3683	11681
Bone meal, Plot 8...........	37.4	2342	23.2	2595	3666	12013
South Carolina rock, Plot 11.	38.9	2346	18.9	2215	3466	11884

DISCUSSION OF RESULTS.

The drawing of conclusions from the results of soil experiments is always attended with more or less uncertainty, as soil and weather variations will bring about what may seem to be contradictions. There are also, often uncontrollable errors introduced through depredations of various kinds.

The quantities of phosphoric acid applied in these tests are rather more than was necessary and more than would be found economical in practice; but it was thought best in planning the experiments to have an excess present and so endeavor to make the results more pronounced than to attempt to conduct the work simply on the basis of profits. The object of the investigations was to establish principles connected with the use of phosphates rather than the limits of the soil requirements.

EFFECTS OF PHOSPHATES ON CORN.

A study of the results of the application upon the corn crop as given in Tables 3, 4, and 7, are not very pronounced in any case. They are rather puzzling in that some of the applications gave slightly lower results than the "nothing" plots, yet in all these cases the differences are small and within the limits of error in such work. The results show that as far as the corn crop is concerned that insoluble phosphates are just as valuable as the soluble phosphates and that phosphate rock was just as valuable as bone-meal. The most striking and best results were obtained from the use of reverted phosphates and the Florida soft phosphates. This result, as a whole, would seem to indicate that corn was able to utilize phosphorous that was not available to other crops. A comparison of the average yields of plots 7, 8 and 11, Table 7, would seem to indicate that the nitrogen in bone-meal was of no value to the corn.

EFFECTS OF PHOSPHATES ON WHEAT.

The results as given in Tables 5 and 7 show quite conclusively that the wheat crop needed a more available source of phosphoric acid than the soil furnished naturally. The soluble sources of phosphoric acid gave the best yields of grain. The best average yield of straw was from the plots receiving slag phosphate. Wheat seemed able to utilize phosphoric acid from all the sources and forms of phosphates tried in this test. The Florida soft phosphate seemed to be the least available source of phosphoric acid for wheat which was the opposite of that for corn. The Nitrogen in bone meal showed its influence on the yields of both wheat (grain) and straw. The results show quite conclusively that a liberal supply of phosphorous is necessary for wheat.

EFFECTS OF PHOSPHATES ON HAY.

The crops of hay in this experiment consisted of mixtures of timothy and clover seeded and treated after the custom usually practiced in this and most Eastern States.

The results in Tables 6 and 7 show that all of the applications of phosphates caused a marked increase in the yields. The hay crop seemed able to utilize all the sources and forms of phosphorous advantageously. All the forms of phosphorous gave better results than that in the soluble condition. Finely ground raw rock and slag phosphate gave much better results in hay than either dissolved rock or bone-meal. The nitrogen or ammonia in the bone-meal did not seem to have any particular influence on the yields. The best average yield of all the plots was from that one to which reverted phosphate of iron and alumina was applied. The results correspond with that of corn.

"NOTHING" PLOTS. (PLOTS 5, 10, 15 AND 20.)

An examination of Table 7, page 126, shows that average total product from the plots receiving no phosphates, was considerable below all the others. With some crops the phosphates produced but little increase in the yield, and in a few instances the "nothing" plots gave higher yields than the ones to which phosphates were applied. This is noticeably the case with corn. The yields of wheat and hay were very low and showed the evident need of phosphorous. The difference in the way the various crops responded to the applications of phosphates shows that they are very different in their feeding habits.

SOLUBLE PHOSPHATES. (PLOTS 1, 2 AND 3.)

An inspection of Tables 6 and 7 will show that the soluble phosphates produced a marked influence on the yields of wheat but not as good an average yield as the insoluble phosphates on the corn and hay crops. The failure of the soluble phosphates to produce better yields of corn was probably due to it stimulating too great a growth in the early stages and thus bringing about an unbalanced condition in the plant development. A comparison of the various sources of soluble phosphates shows but little difference in the total and average yields, yet the difference which does exist is in favor of the most concentrated forms. The dissolved phosphate rock gave better yields of wheat, grain and hay than the others but did not seem to do as well on corn and the straw of wheat. The figures for the double superphosphate, which is made from rock phosphates, and dissolved boneblack are almost exactly the same.

REVERTED PHOSPHORIC ACID. (PLOTS. 4 AND 6.)

The plots receiving the phosphates in the reverted forms gave better total yields for the eleven crops and better average yields of corn and hay, than the soluble phosphates, though not quite so large yields of wheat. These results would seem to confirm the generally accepted theory that reverted phosphoric acid has just as great an agricultural value as soluble phosphoric acid. A comparison of reverted phosphates of lime and reverted phosphates of iron and alumina, (Table 7, plots 4 and 6 respectively,) shows in every instance with every crop yields in favor of the reverted phosphates of iron and alumina.

INSOLUBLE PHOSPHATES.

(PLOTS 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21, AND 22.)

An examination of Table 7 shows that the total average yield of these plots to be slightly more than that from the soluble phosphates plots. On analyzing the average yields in this table of summaries it will be seen that the wheat responded better to the soluble than the insoluble phosphates but the corn and hay crops did better on the insoluble phosphates.

A study of the various insoluble phosphates shows that the bone-meal stood first on wheat, third on corn and last on hay; and second on total average yield. South Carolina rock stood first on hay, second on corn and third on wheat. Florida soft phosphate stood first on corn, third on hay and last on wheat. The slag phosphate stood second on hay and wheat and last on corn, yet was first on the total average yield.

A comparison of bone-black, bone-meal and finely ground S. C. rock (plots 7, 8, and 11 in Table 7) shows the bone-meal to stand first and the S. C. rock second as to total average yields; but in this comparison it must be remembered that the bone-meal also furnished some nitrogen and to this extent had an advantage over the others. If we compare the rock with the bone-black, which is really bone-meal with its nitrogen expelled, then we see that the rock produced just as good yields as the bone.

EFFECTS OF GREEN CROPS ON INSOLUBLE PHOSPHATES.

The effects of the green crops during the latter half of these experiments is just the reverse of the former part as reported in Bulletin No. 68. The results in Table 7 show in the total average yield and in the average yield of all crops decidedly in favor of the rye. This may be in part due to the fact that the rye used in former years was just beginning to break up and be available. Again, it may be due to the fact that the crimson clover did not do so well in recent years, owing to weather conditions, and consequently did not furnish as much organic matter as the rye. Again, the rye furnishing a great mass of matter which decomposed slowly probably gave a drainage to the land which was advantageous during the excessively wet seasons which prevailed the last four years of this experiment. The failure of the crimson clover to maintain its former position during the last few years can not be accounted for and will make further study of this matter very desirable.

TABLE VIII.

Relative Producing Capacity of Plots when Receiving Uniform Treatment.

(Yields in pounds per acre.)

Plot No.	WHEAT—1899.		1900	1901	Total of 3 Crops, lbs.	Average Yearly Yield, lbs.
	Grain, lbs.	Straw, lbs.	Hay, lbs.	Hay, lbs.		
1.	1535	2800	4050	4010	12395	3099
2.	1415	2630	3500	3150	10695	2674
3.	1835	3565	3600	3900	12900	3225
4.	2130	4070	4500	3750	14450	3612
5.	2120	3980	4550	4050	14700	3675
6.	2100	4300	3450	3750	13600	3400
7.	2190	4310	4350	4100	14950	3737
8.	2165	4100	2500	4400	13165	3291

TABLE IX.

Yield of Plots when Fertilized with Different Sources of Phosphoric Acid.

(Yield in pounds per acre.)

Plot No.	Kind of Phosphate.	CORN, 1902.		CORN, 1903.		WHEAT, 1904.		Hay, 1905.	CORN, 1906.		Total Yield, 5 Crops.	Average Yield.
		Grain.	Fodder.	Grain.	Fodder.	Grain.	Straw.		Grain.	Fodder.		
1.	South Carolina rock	3500	3000	2410	1550	350	400	1600	3485	3000	19235	2137
2.	Dissolved South Carolina rock.	3190	3000	2185	1450	660	740	2450	2960	2500	19135	2126
3.	Dissolved South Carolina rock and lime.	3800	3050	2690	1600	415	485	3000	2485	2000	19535	2171
4.	Nothing	3670	3050	3570	2300	245	555	1950	3000	2250	20590	2288
5.	Tennessee rock	4050	3000	3910	2500	550	600	3200	3660	2650	24120	2680
6.	Florida soft rock	3390	3300	4355	2850	665	1335	3450	3920	2500	25765	2863
7.	Virginia rock	3250	2300	4875	3250	600	900	4500	3800	2900	26385	2932
8.	Precipitated Phosphate.	3300	2800	4195	2200	840	1310	4200	3240	2400	24485	2721

TABLE X.

Showing the Relative Yields and Influence of Different Sources of Phosphoric Acid on Scale of 100.

(Results expressed in per cents.)

Plot No.	Kind of Phosphate.	Rate of Yield Before Experiment.	Rate of Yield During Experiment.	Difference.	Relative Increase.
1.	South Carolina rock.............	83	73	—10	10
2.	Dissolved South Carolina rock....	72	72	00	20
3.	Dissolved South Carolina rock and lime.*	86	74	—12	8
4.	Nothing........................	97	77	—20	00
5.	Tennessee rock..................	98	91	— 6	14
6.	Florida soft rock................	91	98	+ 7	27
7.	Virginia rock	100	100	00	20
8.	Precipitated rock	88	93	+ 5	25

*Lime applied at the rate of 20 bushels per acre.

EXPERIMENT NO. 2—DISCUSSION OF RESULTS (TABLES VIII, IX AND X.)

In order to test some sources of phosphoric acid not provided for in the experiment started in 1895, eight more plots of one-tenth acre each were laid out and fertilized according to the schedule given in Tables 9 and 10. The phosphates were applied so as to furnish each plot the same quantity (150 lbs. per acre) of phosphoric acid P_2O_5). These plots had been cultivated in a uniform manner for several years before starting the experiment so as to know something of their relative producing capacity. The results of these yields are given in Table 8. From which it is seen that there was considerable variation. The yields for the five years of the experiment are given in Table 9. The weather conditions during the period of the test were not so favorable as during the previous period; consequently the average yields were lower than during the preliminary period. Compare results in Tables 8 and 9. In order to have these figures in a shape for comparison the acreage yields in Tables 8 and 9 were reduced to percentage, or scale of 100 basis. On examination it was found that plot 7 gave the highest average yields in both Tables 8 and 9, consequently it was decided to call that yield 100 in each case and determine the relative yields of the other plots upon that basis. The results on this basis of determination are given in Table 10. An examination of the column headed "difference" in Table 10 shows considerable variation in the comparative relative yields. An examination shows that the "nothing" plot had the greatest decrease in yield. Assuming that had it not been for the influence of the phosphate applied the other plots would have shown the same rate of decrease, consequently in reality the phosphate exerted a beneficial influence or in other words produced an increase. Working on this basis, if we call the decrease on the "nothing" plot 4, normal or zero, then express the relative yields of the other plots in the same terms we have the figures (per cents) indicated in the "relative increase" column of Table 10.

From these results we see that Florida soft phosphate gave the best results which are harmonious with the results given in Table 7. The next highest natural phosphate was the Virginia phosphate; which is also largely an iron and alumina phosphate. The finely ground Tennessee and South Carolina phosphates produced about the same effect. The dissolved S. C. rock in this series gave twice as good results as the undissolved. The liming of the land each time the phosphate was applied seemed to produce a harmful effect and while this was not to be expected, yet it showed that the failure of dissolved phosphates to act in the previous experiments was not due to the acidity of the soil. The precipitated phosphates applied to plot 8 is a by-product in the manufacture of chemicals. The good result it gives, to some degree at least, might be attributed to its fine mechanical condition. No doubt its being a precipitated product that its mechanical condition and physical properties make it much easier for plants to utilize than a product which is only finely ground. The results on this plot would also substantiate the theory advanced for the mechanical results attained in the use of soluble phosphates and their precipitation in the soil. These results also suggest that the theory of the formation of the soft phosphates and the iron and alumina phosphates was by some precipitation process.

CONCLUSIONS.

In the matter of drawing conclusions it is always well to be cautious and conservative. This policy is particularly applicable to cases like the one under consideration at this time. There is no doubt that some of the results reported upon in this connection are at variance with the principles commonly taught and the practice generally followed in the matter of fertilizers. With these considerations it would be well for those persons who desire to apply these results or to use any different source or form of phosphoric acid from that which has been successfully and satisfactorily used in the past, to do so on a limited scale in order to be satisfied that the results will hold under the particular conditions which may surround each case.

The total average results as given by the figures in Table 7 show that the finely ground insoluble phosphates; that is, phosphates which have not been treated with sulphuric acid (oil of vitriol) will produce as much and in some cases more crop than that produced by the so-called dissolved or soluble phosphates. The results obtained with the insoluble phosphates has cost usually less than one-half as much as that with the soluble phosphates.

The results show decidedly that plants are able to utilize insoluble rock phosphates.

The results with slag phosphate (mostly a tetra-phosphate of lime) gave slightly greater total average yields than bone-meal or dissolved phosphates, and at much less cost. The slag phosphates seemed to be specially adapted to grass. These results would seem to substantiate the claim of some people that this phosphate should be classed as mostly available and that official methods of analysis should be so modified as to give them more equitable rating.

Bone-meal was the best form of insoluble phosphate on wheat but its accumulative and supposed lasting effects did not show on the grass.

Bone-meal had an advantage over all other phosphates in furnishing some nitrogen.

The iron and alumina phosphates proved in all cases to be valuable sources of phosphoric acid and it would seem that they deserve a higher rank as a fertilizer than that usually accorded them.

The use of an abundance of organic matter in the soil when insoluble phosphates are applied was evidently a necessity for their best effects.

SUMMARY OF PRINCIPAL RESULTS.

1. The highest total average yield was obtained with reverted phosphates.
2. Reverted phosphate or iron and alumina produced a higher yield than reverted phosphate of lime.
3. Insoluble phosphates produced a slightly higher total average yield than soluble phosphates and at about one-half the cost.
4. Slag phosphate produced better results than bone-meal and at less cost.
5. Soluble phosphates produced the best yields of wheat.
6. Florida soft phosphate produced the best yield of corn.
7. Reverted phosphates produced the best yield of hay.
8. Insoluble S. C. phosphate rock produced a higher total average yield than dissolved S. C. rock.
9. Insoluble S. C. phosphate rock produced a little higher yield than bone-black.
10. Bone-meal produced a better yield of wheat than any other source of insoluble phosphate; but all other sources produced better grass.

APPENDIX.

There is a great demand for general information on phosphates and for the benefit of those who do not have our Bulletin No. 68, and desire some more detailed information on the various forms of phosphoric acid some of the matter contained in that bulletin is given here with additions and corrections.

HISTORY OF THE USE OF PHOSPHATES.

There is no definite record as to the time when the use of phosphates first came into existence, but as far as can be judged from the early records and writings upon agricultural topics, there seems to be but little doubt that the first commercial fertilizers ever used were chiefly phosphatic in their nature, and the good results which attended their application was mainly due to phosphoric acid.

From some notes of Varro it might appear that phosphates may have been used to some extent even B. C., but it is very sure that even if such were the case, it was not until comparativly recent times that the value and need of phosphoric acid was actually recognized. Writers record that upon the first invasion of Britain by the Romans, the natives were found using phosphatic marls to obtain better crops. But the practices were the result of accident or mere observation, and were not based upon any knowledge of the relation of soils, fertilizers and plants. The same is true of the practice of the Indians of putting fish in their hills of corn, as observed by the early settlers of America.

That there were no very definite ideas in the minds of the early users of phosphates or other mineral plant foods, at least ideas which correspond with the present existing theory of the relations of plants to mineral plant foods, is evidenced by the fact that the Prussian Academy of Sciences, in the year 1800, offered a prize for an investigation to decide whether the mineral matters found in plants are taken up from the soil or whether they are produced in the plants themselves by vital power. This question was treated by Schroader, whose decision was in favor of the latter opinion.

This opinion, though probably quite generally held, did not remain long in force, for Saussure, in 1804, declared that the mineral matter of humus contributed in a certain degree to fertility, since the same minerals are found in the ashes of plants. Sir Humphrey Davy was the first to consider the mineral constituents essential for the development of plants, as is evidenced by his statements in Elements of Agricultural Chemistry, London, 1814, to the effect that: "The chemistry of the simpler manures (the manures which act in very small quantities, such as bone dust, gypsum, alkalis and various saline substances), has hitherto been exceedingly obscure. It has been generally supposed that these materials act in the vegetable economy in the same manner as condiments or stimulants in the animal economy and that they render the common food more nutritive. It seems, however, a much more probable idea that they are actually a part of the true food of plants, and that they supply the kind of matter to the vegetable fibre which is analogous to the bony matter in animals stomachs." Springel, in his Theory of Manuring, published in 1839, was the second to express an opinion to this same effect. He said:

"We can accept it as an indisputable fact that mineral matters found in plants are real nutrients for them, and that it is not their action upon humus which makes them important, since gypsum, potassium, sulphate and calcium phosphate do not at all act upon the humus."

Closely following the statements of Springel, came (in 1840) the published results of the researches of Justus von Leibig, Leibig's results laid the foundation for our present agricultural chemistry, and entitled him to the designation of the "Father of Agricultural Chemistry."

While, as has been stated, mills for grinding bones existed early in the nineteenth century in France and England, and enterprising men went so far as to dig up battlefields and unearth thousands of tons of bones for agricultural purposes, and it is even claimed that the credit for making the first superphosphate is due to Sir James Murray, which was done in 1877, yet it was made without any real knowledge of the change which took place or application of the practical value accomplished.

As a result of his researches, Leibig pointed out that by treating bones and mineral phosphates with sulphuric acid, the insoluble phosphoric acid would be changed to a soluble form, and a considerable quantity of gypsum (sulphate of lime or land plaster), would be formed at the same time. The experiments of Leibig were substantiated by those conducted by the Duke of Richmond in comparing fresh and degelatinized bone from which he came to the conclusion that bones owed their fertilizing value not to gelatins or fatty matter, but to their large percentage of phosphoric acid. These experiments were still further confirmed by the results, shortly afterwards published by Boussingault. This set all uncertainty with regard to the value of phosphoric acid at rest and established its value and necessity on a permanent foundation, marked a distinct epoch in the use of phosphates, which, from that time, has rapidly spread and been constantly increasing.

THE ROLE OF PHOSPHORIC ACID IN PLANTS.

The function which phosphoric acid performs in plants is quite varied, yet in all cases exceedingly essential. The present status of this subject has been fully set forth by Dr. Oscar Loew, in Bulletin No. 18, of the Division of Vegetable Pathology, U. S. Department of Agriculture, "On the Physiological Role of Mineral Nutrients." The principal points which it might be well to mention here are that the chlorophyll to which the green color of plants is due, can only be formed in the presence of phosphoric acid and, hence, all the essential functions which are closely related to the chlorophyll are dependent upon this element. Relatively large proportions are found in yeast cells, in seed just forming and numerous other microscopic organizations which are playing so important a part in the growth of plants. Proper embryo development of seeds seems to be dependent upon phosphates, and some observers have claimed that the total mass of protein in seeds is increased by an increased supply of phosphoric acid.

PHOSPHOROUS, PHOSPHORIC ACID OR PHOSPHATES.

Phosphorous compounds are absolutely necessary for the maturity of plants and the formation of seed for their reproduction. It has been well established that the salts of phosphoric acid, or phosphates, as they are called, are the only sources from which the phosphorous of plants can be derived. Phosphoric acid is a combination of the element Phosphorous (P) with Oxygen gas (O). In phosphates the phosphorous and oxygen unite in the proportion of two parts of the former to five of the latter forming what is commonly designated as phosphoric acid, and this union is expressed by the sign or symbol P_2O_5. Phosphorous, when uncombined with other elements, is a yellowish, waxy looking, solid substance. It is soft and can be cut as easily as ordinary bees-wax. It is very poisonous. It ignites easily and therefore has to be kept under water. When phosphorous burns it simply unites with the oxygen of the air, forming phosphoric acid P_2O_5).

Phosphoric acid usually occurs in the soil in combination with lime, magnesia, alumina and iron. These phosphates are all practically insoluble in water, that is they are dissolved by pure water so slowly and to so slight an extent that they sustain no appreciable loss in the soil by drainage water. Hence the quantity in the soil is diminished almost wholly through the agency of crops. The amount of phosphoric acid even in a fertile soil is comparatively small. A ton of good soil will contain 3 pounds; many will contain less, and some considerably more. On this basis an acre of average soil would contain to the depth of 9 inches, about 4,500 pounds of phosphoric acid. Analysis of the nothing plots showed the soil used for the experiments reported in this bulletin to have weighed about 1,812,964 lbs. per acre to the depth of six inches and to have contained 2719 lbs. phosphoric acid. A large portion of this is not available to crops. The character of the soil effects very considerably the conditions of the plant food. One of the problems that confronts the farmer is to use such methods in soil management as will convert the plant foods which the soil contains, into forms available for crops.

FORMS OF PHOSPHORIC ACID.

As has already been stated, phosphoric acid exists in soils in combination with lime, magnesia, alumina and iron, and it is in these same combinations that is found in the various sources from which phosphates are manufactured. For the manufacture of fertilizer and in agriculture, the phosphate of lime is the most highly prized.

In nature the phosphates are found in a form, termed insoluble, which means that they are practically insoluble in water.

In manufacturing fertilizer from phosphate of lime the aim has been to change it from the insoluble condition to a soluble condition which would be more available to plants. In the natural and insoluble state the phosphate exists in what is chemically known as tri-calcium phosphate, (three-lime phosphate), and in the course of manufacture this is changed chemically so that, at the end of the operation, there exists four kinds of combinations of Calcium (lime) and phosphoric acid, which are as follows:

(1) Soluble phosphate of lime, or mono-calcium phosphate.
(2) Reverted phosphate of lime, or di-calcium phosphate.
(3) Insoluble phosphate of lime, or tri-calcium phosphate.
(4) Tetra-calcium phosphate, or four-lime phosphate.

(1) SOLUBLE PHOSPHATE OF LIME.

This is properly known under several other names as "Superphosphate," "Superphosphate of lime," "Acid Phosphate," Acid Phosphate of lime," "Water soluble phosphate," "Acid calcium phosphate," "Mono-calcium phosphate," and "One lime phosphate." Phosphoric acid does not occur naturally in the soluble state.

Soluble phosphoric acid is made by treating bones or mineral phosphates with sulphuric acid (oil of vitriol). The chemical change which occurs is practically as follows: Sulphuric acid and water being applied to the materials containing insoluble phosphates (tri-calcium phosphate), the sulphuric acid combines chemically with two parts of lime and forms sulphate of lime or gypsum (Land Plaster), while the water unites with the phosphoric acid and one part of lime, forming mono-calcium or soluble phosphate of lime. The substances being mixed, it is a natural chemical action or reaction that takes place with the result stated. The total conversion of the insoluble to the soluble form, cannot be accomplished without using such an excess of sulphuric acid as would be injurious to seeds and roots of plants which would come in contact with the fertilizer, and also would make the fertilizer of such a mechanical condition as to be difficult to handle and apply. In practice, less acid is added than is necessary to wholly convert all the phosphoric acid to the soluble form, consequently more or less of all the forms of phosphoric acid are found to be present after the fertilizing materials have been treated or dissolved. Leibig, in 1840, was the first person to suggest the treatment of bones and mineral phosphates with sulphuric acid, for the purpose of rendering the phosphoric acid available for plants. This may be said to be the beginning of the use of genuine artificial fertilizers. In the course of dissolving phosphates some of the phosphoric acid is set entirely free and will be found as free phosphoric acid in freshly made goods, but this will remain so for only a comparatively short time. It will in time act on the insoluble phosphates contained in the fertilizer. The water-soluble phosphoric acid is readily distributed in the soil, and is in a form that can be immediately absorbed by roots and used by plants as food, but unfortunately the water-soluble phosphoric acid will not remain long in the soil in this condition, for, on coming in contact with the lime, magnesia, etc., in the soil, it reverts to a condition insoluble in water. In reverting this water-soluble phosphoric acid is precipitated in such a way as to form a fine powder or coat over the particles of soil, and is thus in a finely divided state and presents a considerable surface which makes it easily dissolved by the soil waters, or the acid exudations of rootlets and thus still possesses a greater availability than any other form of phosphoric acid.

(2) REVERTED PHOSPHATE OF LIME.

Reverted phosphate of lime, also spoken of as "Reverted phosphoric acid," "Reverted calcium phosphate," "Precipitated phosphate of lime," "Citrate soluble phosphate," "Neutral phosphate of lime," and "Bi-calcium phosphate," is quite insoluble in pure water, but is easily dissolved in water containing carbonic acid or salts of ammonia and in weak acids. The term reverted was originally intended to imply that this phosphoric acid had once been soluble, but for some cause, had "gone back" to a form insoluble in water. This probably does take place to a limited extent, but as a matter of fact in the course of manufacture there is not sufficient acid used to make all the phosphoric acid soluble, and some of the tri-calcium phosphate loses only one part of lime, and thus leaves some di-calcium phosphate remaining. As has been stated some phosphoric acid is set entirely free which will unite with available phosphoric acid and bring some of it to the so-called reverted form. This form of phosphoric acid is readily assimilated by plants, because the soil and solutions from the plant roots usually contain acids strong enough to dissolve it. Reverted phosphoric acid is therefore considered nearly as valuable as a plant food as the water-soluble form. Reverted phosphoric acid is often met with in small quantities in nature in connection with some insoluble phosphates, guanos, limes and other organic matter.

AVAILABLE PHOSPHORIC ACID.

In the commercial world and in stating the results of an analysis the percentage of soluble phosphoric acid and the reverted or citrate soluble phosphoric acid are added together and the sum called available phosphoric acid.

(3) INSOLUBLE PHOSPHORIC ACID.

This is known under several names, as "Insoluble calcium phosphates," "Tri-calcium phosphate," "Bone phosphate of lime," and "Normal calcium phosphate." This form is called insoluble because it does not dissolve in water or weak acids as does the soluble or reverted phosphoric acid; but requires some strong acid to cause its decomposition or solution.

Insoluble phosphoric acid is found in nature in large quantities some of the chief sources of which will be noticed later.

Insoluble phosphates are found everywhere in the soil and most of them are of but little value to the farmer because they are not easily dissolved and can therefore be utilized but slowly by plants. One of the chief points under experimentation and reported upon in this bulletin, was to test means for rendering these insoluble phosphates available to plants through the agency of crops and cultivation without the intervention or use of sulphuric acid.

(4) TETRA-CALCIUM PHOSPHATE.

Tetra-calcium phosphate, or four-lime phosphate, is a form of phosphoric acid of recent discovery, and has been found to exist in slag phosphates. It contains more lime in proportion to phosphoric acid than any other form of phosphate. While it is insoluble in water, it has been found to be more available to plants than insoluble phosphate of lime (tri-calcium phosphate).

The following table gives the chemical composition and differences of the four phosphates of lime:

TABLE XI.

Chemical Composition of the Four Phosphates of Lime.

	Calcium, Per Cent.	Phosphorous Per Cent.	Oxygen, Per Cent.	Hydrogen, Per Cent.
1 Soluble phosphate of lime.	17.1	26.5	54.7	1.7
2. Reverted phosphate of lime.	29.4	22.8	47.0	0.8
3 Insoluble phosphate of lime.	38.7	20.0	41.3	....
4. Tetra-calcium phosphate.	43.7	17.0	39.3	....

Or stating it in another way:

	Phosphoric Acid, P_2O_5.	Lime, CaO.	Water, H_2O.
1. Soluble phosphate of lime............	60.68	23.93	15.39
2. Reverted phosphate of lime..........	52.20	41.18	6.62
3. Insoluble phosphate of lime..........	45.81	54.19	....
4. Tetra-calcium phosphate............	38.79	61.21	....

TOTAL PHOSPHORIC ACID.

Total phosphoric acid is the sum of all the forms of phosphoric acid which a given fertilizer contains. In a dissolved rock, for instance the total is equal to the sum of the soluble, reverted, and insoluble phosphoric acid contained therein.

METHODS OF MANUFACTURING SOLUBLE PHOSPHATE.

The process of manufacturing soluble phosphates from bones or mineral phosphates is not very complicated, yet requires some chemical knowledge and experience, and facilities for carrying on the operation.

The raw phosphates, whether of animal or mineral origin, are quite variable in their physical condition and chemical composition, yet the phosphoric acid will be found to be combined with lime, in the proportion of one part of the former to three of the latter forming the tri-calcium phosphate.

The chief result which the manufacturer desired to arrive at is to make the tri-calcium phosphate soluble in water or in neutral ammonia citrate. To do this the chemist has worked upon the following basis: Sulphuric acid is known to be more energetic in its action at ordinary temperatures than any other acid used in industry. It, therefore, has the power of displacing all other acids from their salts, and of taking their bases to itself to form sulphates; which, for the most part, are quite staple and easily handled substances. The acids chiefly present in natural phosphates are phosphoric, carbonic, fluoric, and silicic. These, when brought in contact with dilute sulphuric acid, are all displaced, and the bases become sulphates. Chemists have determined how much sulphuric acid is required to displace each of the various acids present, and to form sulphates with the bases with which they are combined, so that, after the composition of a natural mineral phosphate has been determined, the amount of sulphuric acid of a given strength which it is necessary to use in order to bring about the desired change of a tri-calcium phosphate to the soluble and reverted forms, can be easily calculated. These amounts have been worked out for practice as expressed in the following table:

TABLE XII.*

One Part by Weight of Each Substance Below Requires. Sulphuric Acid by Same Unit of Weight.

	At 48°B.	At 50°B.	At 52°B.	At 54°B.	At 55°B.
Tri-calcium phosphate...	1.590	1.517	1.446	1.382	1.352
Iron phosphate...........	1.630	1.558	1.485	1.420	1.390
Aluminum phosphate....	2.025	1.930	1.839	1.756	1.721
Calcium carbonate.......	1.640	1.565	1.495	1.428	1.411
Calcium fluoride.........	2.060	2.010	1.916	1.830	1.794
Magnesium carbonate....	1.940	1.860	1.775	1.690	1.660

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*W. H. Wiley's "Principles and Practice of Agricultural Analysis," Vol. II., P. 155.

Example—Suppose for example a phosphate of the following composition is to be treated with sulphuric acid, viz:

Moisture and organic	4.00 per cent.
Calcium phosphate	55.00 per cent.
Calcium carbonate	3.00 per cent.
Iron and Aluminum phosphate, nearly all Alumina	6.50 per cent.
Magnesium carbonate	0.75 per cent.
Calcium fluoride	2.25 per cent.
Insoluble	28.00 per cent.

Using sulphuric acid of 50° B., the following quantities will be required for 100 kilograms.

	Kilos of acid required.
Calcium phosphate, fifty-five kilos	83.44
Calcium carbonate, three and a half kilos	5.48
Calcium fluoride, two and a quarter kilos	4.52
Aluminum and iron phosphate, six and a half kilos	12.55
Magnesium carbonate, three-quarters of a kilo	1.40
Total	107.39

The material before treatment is always finely ground so as to facilitate the chemical action. After the treatment has been completed the mass is dried and ground for use.

The materials which are chiefly used as sources of phosphoric acid in fertilizer are given in table XIII, page 144, together with their average composition. A more detailed description of those phosphates which were used in the experiments under consideration have already been given.

AGRICULTURAL AND COMMERCIAL VALUE OF PHOSPHATES.

Notwithstanding the numerous explanations that have been given in the agricultural press, in bulletins and by lecturers at farmers' institutes, etc., of the difference between the agricultural value and the commercial value of fertilizers, farmers are continually confounding the two values, and falling into the error that because one fertilizer has a higher commercial value than another it must necessarily have a higher agricultural or fertilizing value as well.

The commercial value of a fertilizer depends upon its abundance, the ease with which it is produced and the amount being used, or, in other words, upon the ever-ruling elements in the commercial world of "supply and demand."

The agricultural value depends upon the ability of the particular fertilizer or phosphate in question to improve the fertility or productive capacity of a particular soil. Hence, it will be seen that the agricultural value, within certain limits, is not directly dependent upon the commercial value (and vice versa), and is a value that changes with different soils.

To illustrate, suppose a particular class of soils contain all the phosphates necessary for crops and that the application of any more phosphates give no returns whatever in increasing yields. This would mean that for that particular piece of land phosphates had no value agriculturally, yet that would not affect the market or commercial value of the phosphate. To illustrate further, sugar has a commercial value of $100.00 per ton, while Dissolved South Carolina rock can be purchased for one-tenth that sum. From a fertilizing standpoint, it is doubtful if an application of sugar would have any effect on the yield of crops, while the phosphate might double them, and thus have double the agricultural value of the sugar. Again, clover hay, for instance, has double the fertilizing and feeding value of timothy hay, yet the commercial or market value of timothy hay is always the more.

The following is the commercial value of phosphoric acid in different phosphatic materials according to the trade valuations.

	Cents per pound.
Soluble phosphoric acid in bone fertilizers	5
Soluble phosphoric acid in rock fertilizers	3
Reverted phosphoric acid in bone fertilizers	4½
Reverted phosphoric acid in rock fertilizers	2½
Insoluble phosphoric acid in bone fertilizers	2
Insoluble phosphoric acid in rock fertilizers	1½
Total phosphoric acid in fine raw bone, tankage and fish fertilizer	3½
Total phosphoric acid in medium bone and tankage	3
Total phosphoric acid in coarse bone and tankage	2½
Total phosphoric acid in cotton-seed meal	4
Castor pomace and wood ashes	4

From these figures it will be seen that the commercial or trade value of 100 pounds of soluble phosphoric acid in a dissolved bone would be $5.00, while 100 pounds in a dissolved rock would be but $3.00. From an agricultural standpoint, in view of all the experiments which have been conducted, the value of phosphoric acid from the two sources would be exactly the same.

Again, the above valuations place a higher valuation upon the total phosphoric acid in cotton-seed meal than that from bone, whereas, when applied, probably there would be no difference so far as phosphoric acid is concerned.

From what has been said it would be plain to every farmer that he should buy phosphate, or indeed, any fertilizer with reference to the value it has to him in increasing the productive capacity of his soil and not purchase solely upon the basis of commercial valuation as represented by agents or tabulated analysis of fertilizers.

DETERMINATION OF AVAILABLE PHOSPHORIC ACID IN SOILS.

The purpose of the agricultural chemical examination of soils, from the earliest time when the science was employed in this way, was to throw some light upon the relations of the various constituents to plant growth and especially to determine the amounts of the essential constitutents which are in a condition to be used by crops, or in other words, "available." There have been numerous methods proposed for distinguishing between available and unavailable plant foods in various kinds of soils, and this problem has occupied the attention of the best minds in agricultural chemistry for many years. No one element in this study has received as much attention as the phosphoric acid.

At the present day there seems to be a general agreement that the use of weak solutions or solvents give results that more nearly correspond to the results obtained by cropping, yet there is much difference of opinion as to the proper acid or solution to use. This condition, no doubt, is due to the variations in the chemical characteristics of the soils experimented upon.

The present status of the results obtained in this research would seem to indicate that it is very improbable that a marked distinction of any kind can be drawn between "available" and "unavailable" compounds of phosphoric acid in the soil, for the reason that it is not probable that any soil contains a compound or group of compounds which can be wholly removed by plants or dissolved by an acid that is "available," before the remaining compounds are attacked. From the very nature of the changes which are taking place in soils, produced either by crops or natural agencies, there must be more or less change and re-arrangement of the elements as different ones are attacked, thus making some phosphates available that were previously unavailable, or even the reverse may take place.

It is probable that of the many methods proposed that none of them will be equally well adapted to all classes of soils owing to the selective power of certain acids for different combinations of phosphoric acid, and they will attack different types of soils with more or less vigor, but in the main the relative action of all acids on all soils will be alike.

Hall and Plymen have recently made an extensive research and review of the methods proposed for available phosphoric acid, and have reached the conclusion that one per cent. solution of citric acid gave results which are most in accord with the known history of soils. On soils well provided with carbonate of lime, there was little difference in the result obtained with the different acids tried.

With the present state of the perfection of chemical analysis of soils it will still be necessary to put much reliance upon the results obtained by the practical use of the various phosphates in connection with the growing of different crops upon a variety of soils.

TABLE XIII.

Giving the Approximate Amount of Phosphoric Acid in Fertilizing Materials.

Materials Containing Phosphoric Acid.	Phosphoric Acid (P_2O_5).				Lbs. in One Ton.	
	Soluble, Per Cent.	Reverted, Per Cent.	Insoluble, Per Cent.	Total, Per Cent.	Available Phosphoric Acid.	Total Phosphoric Acid.
Apatite	......	......	......	38.0	......	760
Bone-ash	......	......	......	35.9	......	718
Bone-black	......	......	......	28.3	......	567
Bone-black (Dissolved)	10.0	0.7	0.3	17.0	334	340
Bone-meal	0.4	6.5	15.6	22.5	138	450
Bone-meal (from glue factory)	......	6.5	22.4	28.9	130	578
Bone-meal (Dissolved)	10.0	5.0	2.5	17.5	300	350
Caribean guano	......	......	......	18.9	......	378
Cuban guano	......	......	......	17.9	......	358
Double Super-phosphate	......	......	4.0	44.0	800	880
Florida rock	......	......	......	30.0	......	600
Florida soft phosphate	......	......	......	24.0	......	480
Keystone concentrated phosphate	0.3	38.2	9.2	47.7	770	950
Mona Island phosphate	......	7.5	14.3	21.8	150	436
Navassa phosphate	......	......	......	34.3	......	686
Orchilla guano	......	......	......	26.8	......	536
Peruvian guano	4.6	3.8	4.9	13.3	168	266
South Carolina rock (ground)	......	0.3	27.7	28.0	6	560
South Carolina rock (floats)	......	0.5	27.5	28.0	10	560
South Carolina rock (Dissolved)	10.5	3.5	2.0	16.0	280	320
Slag Phosphate (American)	......	......	......	21.0	......	420
Slag Phosphate (German)	......	......	......	30.0	......	600
Tennessee Phosphate rock	......	......	......	35.0	......	700

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CONTROL OF INSECT PESTS AND DISEASES OF MARYLAND CROPS.

By J. B. S. Norton, Pathologist, and T. B. Symons, Entomologist.

ENORMOUS LOSSES FROM INSECTS AND DISEASES.

It is not possible to accurately estimate the exact losses from these causes, as crops attacked are influenced in many ways. The loss of foliage may not show direct injury to the fruit product of an apple tree until months afterward, when great reduction in producing power is apparent and referable to the previous leaf injury; but that the reduction in amount produced is very great cannot be doubted in cases where the loss is direct and can be easily measured. In the report of the State Entomologist for 1905 it is estimated that over $5,000,000 is annually lost to this State through the work of injurious insects. In the report of the State Pathologist for 1904 a very conservative estimate taken from the reports of various farmers regarding different crops shows a yearly loss to the State of over $1,000,000 from plant diseases that could have been prevented.

Few realize the enormous loss unless some disease or insect attacks with unusual severity some fruit, grain or other product; and the annual loss of from 10 to 20 per cent. of the crops through disease of foliage, stem, etc., is scarcely noticed, or taken as the usual condition. What business man could hope to succeed and neglect such a constant waste.

CAN THE LOSS BE PREVENTED?

The control of insects and plant diseases by scientific methods is comparatively new and some of the most important problems connected therewith are yet unsolved and afford serious work for many investigators. But the last quarter-century has seen rapid development of many certain and profitable methods of controlling these pests. It can be said, then, that the greater part of the loss mentioned above can be prevented and with profit. The experience of many growers who are successfully spraying and making money by it, and those who are following new methods of growing crops to overcome the loss from disease and insects, will give affirmation to this statement. There is no excuse for the loss in wealth to the State through neglect to apply the known means of saving it. It is the purpose of this bulletin to discuss some of the means by which this can be done, and the reader will find the information arranged under suitable headings in the following pages, so that he may find what is the trouble with any particular crop and how to treat it most economically to prevent loss. The principal fungicides and insecticides and the best instruments for applying them are given, with the methods of use.

HOW CROPS ARE INJURED.

A healthy apple tree, corn stalk, potato plant, or rose bush may be regarded from the standpoint of the grower as a machine for the production of the desired apples, corn, potatoes or roses. The machine is fed with air, water and various mineral substances from the soil, and these are manufactured by it into the desired fruit, grain, vegetable or flower crop. When anything happens so that the machine does not produce as much as it should, we say it is diseased. Something may be wrong with its surroundings, so that the plant cannot get the necessary supplies to keep its own body in working condition and produce the materials desired by the farmer. The soil may lack the necessary materials, it may be so dry that they cannot be taken up, or so wet that the roots die for the lack of oxygen—actually suffocate—or salt or other substances that prevent the taking up of water may be in the soil, or the temperature may be so low or so high that proper growth cannot take place, or plant tissues or organs may be actually killed by the low temperature. The investigation of how to regulate such conditions affecting the health of plants has usually fallen to the student of agriculture.

One of the greatest causes of injuries to plants (or of diseases) is the influence exerted upon them by living things, which carry on their existence by destroying our crops or taking from their substance. These parasites may belong either to the animal or vegetable kingdom. By far the greater injury from animals is done by the insects. The most of the injury done to crops by vegetable organisms, aside from weeds which grow among them, is done by parasitic fungi and bacteria.

HOW INSECTS INJURE CROPS.

It would not be practicable to enumerate here the great variety of ways in which insects do their injury to the many crops and products, for the tediousness of relating in detail, as far as we know, the many peculiar instincts and habits of these little six-footed animals would be wearisome to the novice. Only the general principles of their attacks need be discussed. It is obligatory on the part of the observer or farmer to first make a careful examination of the manner in which the injury is being done, whether by an insect or other animal or fungus disease, for, without careful scrutiny one often makes a wrong diagnosis. After being sure of our ground, so to speak, in this determination, we must then decide how the injury was accomplished before we can intelligently employ any of our common insecticides. The majority of our insects which injure crops or products may be divided into two classes. First, those insects that eat or chew the foliage or other parts of the plant, and, second, those that suck the juices from different parts of the plant. To a third class may belong those insects that do injury by mechanical means, or by both the above mentioned ways, either biting or sucking.

The mouth-parts of insects belonging to the first class are usually fitted with strong side jaws or mandibles, accompanied by a pair of lesser jaws or maxillae, aided by palpae, and with upper and lower lips, to assist them in taking hold and biting and chewing their food plant or plants which they do only to sustain life and multiply. Such an insect with mouth-parts is shown in Figure 1.

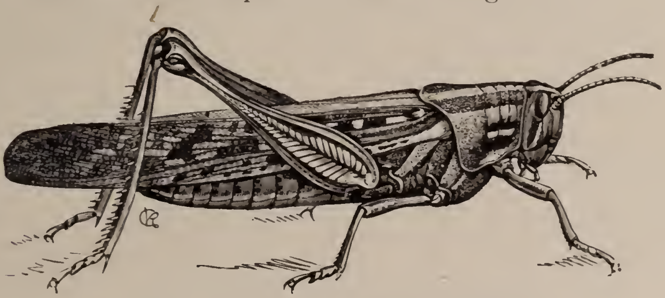

Fig. 1—Insect with biting mouth-parts.

Those insects which belong to the second class have a totally different form of mouth-parts. Here we have, instead of the jaws, lips, etc., a more or less extended beak formed usually of different parts,

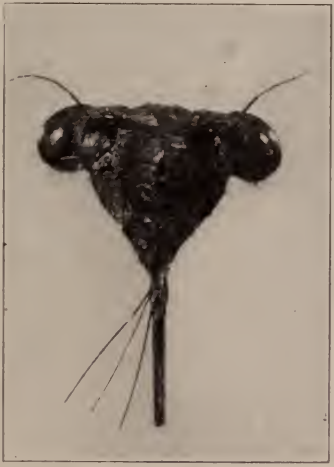

Fig. 2—Head of insect with sucking mouth-parts.

forming a tube and terminating in setae or pointed lancelets, which enable the insect to pierce the external tissues of plants in order to secure the juices from which it derives its nourishment. Figure 2 shows a typical form of sucking or haustellate mouth-parts.

To the third class belong those insects which are fortunate in having their mouth-parts formed for either biting or sucking, giving them greater advantage in securing food. A very few of our common pests, however, can be placed in this class, it being only necessary to mention it here as variations in the anatomy of the mouth-parts of these little animals. Aside from the insects that injure the farmers' crops there are many other animals, not insects, which are usually placed by the novice in the same category, and, accordingly, are sent to the entomologist to consider. Of these may be mentioned the mites, spiders, ticks, etc. It may be stated here that the remedies employed for a given type of insects will equally apply in combating other animals that do similar injury.

HOW TO COMBAT INJURIOUS INSECTS.

The fundamental facts of insect control are: First, to be able to distinguish the manner in which the pest does its injury; second, to be thoroughly familiar with its life history; and, third, to apply the remedies, if such are known, in a thorough manner.

In general, one of three methods is employed in combating any common pest. First, the application of an arsenical, or stomach poison, for those insects which do their injury by eating the foliage and other parts of plants; second, treating with a contact insecticide those insects that suck the juices of plants; and, third, the employment of either mechanical means or cultural methods for those insects that cannot be attacked in a practical manner by the preceding methods.

There are various means of applying the different insecticides.

Sprays.—The majority of stomach poisons and many of the contact insecticides are applied in the form of a fine spray on the foliage or other parts of plants. It consists of diluting the insecticide to the proper strength by water and applying by means of a spray pump. The time of application varies with the insects.

Dusting.—At times both a stomach poison as well as a contact insecticide can be applied in the form of a dust spray. It consists of dusting the insecticide onto the plants by the use of a powder gun or by other means. In applying an arsenical in this manner it is generally diluted by either land plaster, or flour, or some similar material, which can be easily dusted on the plants. Many experiments have been conducted recently with a view of testing the superiority of this method over liquid spraying, but results do not justify a recommendation in its favor. In mountainous districts, where the transporting of the spray pump and the liquid spray, which is much heavier than the dust material, is rather difficult, this method has its advantages.

Gases.—While the employment of gas in controlling insect pests is a form of contact insecticide, it is usually considered under a separate head, for its application is quite different from the usual manner of applying insecticides. Many pests can be reached by this means when it is impossible to employ other treatment effectively. A tight enclosure and an accurate estimate of the chemicals to be used is necessary in fumigating any material or place to destroy insect pests.

Mechanical Means.—There are many insects which cannot be controlled by the application of insecticides. In some cases it is practical to employ some form of mechanical means. This is accomplished by means of the hand and different mechanical devices. Illustrations of the method are worming peach trees to destroy the larvæ of the peach-tree borer, and jarring plum, or other fruit trees, in the spring to catch the adult plum curculio.

Trap Crops.—Some of our pests prefer one kind of plant above another, but if the preferred food is absent it satisfies itself by feeding on the food plant that is available. In order to prevent injury on the latter plant, which may be more valuable to a farmer in a given locality, he can plant the preferred food plant as a trap crop for the pest, the insect can then be effectively treated on the trap crop by means which may be prohibitive on the regular crop.

Rotation of Crops.—Too much care cannot be exercised by the farmer in a judicious rotation of crops. This is important not only from the point of insect attack, but also that of fungus injury, soil management and fertilization. Often he can avoid serious injury from any given pest the following season by a proper rotation of crops. Many insects that do serious injury to plants multiply rapidly if the crop is grown in the same soil year after year, consequently the injury steadily becomes more pronounced.

Resistant Varieties of Crops.—Not only does the selection of resistant varieties apply in controlling some plant diseases, but it should be employed in combatting insects. Many instances can be cited where an insect will at times totally destroy a certain variety of plant, while close at hand another variety of the same plant seems to resist attacks of the pest. In such cases, of course, the resistant varieties should be selected for planting.

Beneficial Insects.—Too much credit cannot be given to the beneficial insects for their activity in keeping many of our dreaded pests in check. As a class the *lady-birds* are the largest, but there are many other forms with predaceous and parasitic habits that aid to an untold amount in checking insects. It is necessary that the farmer familiarize himself with many of the beneficial insects, for without this we shall often be exposed to needless alarm and expense, perhaps, in fighting by artificial remedies an insect already in process of rapid extinction by natural causes, even giving up in despair just at the time when the natural checks upon its career are about to lend their powerful aid to its suppression. We may also, for the lack of this knowledge destroy some of our best friends under the supposition that they are the author of the mischief, which they are really exerting themselves to prevent.

Birds.—It is seldom that a farmer or horticulturist realizes the usefulness of birds in the protection of his crops. True it is that they repress insect criminals and charge us at a certain rate for doing so by helping themselves to produce. We observe birds helping themselves to our wheat or fruit and are ready to destroy them for their injury before considering the very much greater loss the self-same bird has saved us by destroying injurious insects, and so, by shooting or trapping it, we are actually taking money out of our pockets. While in general this is true, yet to a greater or less extent some species are more beneficial, and likewise some more injurious than others.

Finally, in the combating of insect pests the fruit grower or farmer must determine for himself the advantages to be gained in the practice of any of the above methods. In addition to our knowledge of the relation of farm or orchard pests to what we may call the natural conditions of their life, we must know how our farming operations affect them, which of our methods of culture stimulate their increase, and which, if any, may help to keep them down, and we must learn where strictly artificial methods should be used to destroy them.

SOME IMPORTANT INSECTICIDES.

The general classes of insecticides have been discussed and the general methods of application will be given later under the title of spraying, and therefore, it is only necessary here to give the different forms of insecticides in common use and the formulae by which they are ordinarily prepared.

ARSENICALS.

This class of poisons are usually applied in the form of a spray or dusted on the plants. When adding a dry arsenical to water for spraying first mix it in a small quantity of water so as to form a paste; then dilute to the proper strength. When used dry the arsenical is usually mixed with land plaster or flour and is applied with a bellows, perforated sack or powder gun.

PARIS GREEN.

Paris Green	1 pound.
Lump Lime (freshly slaked)	2 pounds.
Water	150 gallons.

This well-known arsenical is commonly used in combating biting insects. On very sensitive foliage, like that of peach, apricot, etc., it is safer to use 200 gallons of water to a pound of poison. Applied dry, the poison should be diluted by twenty times its own weight of flour or plaster.

It is often combined with Bordeaux mixture, a fungicide, in the same proportion as above, substituting Bordeaux mixture for the lime and water.

ARSENATE OF LEAD.

Arsenate of Lead	2 to 4 pounds.
Water	50 gallons.

This arsenical is used by many in preference to Paris green, for it is the least caustic in its effect upon foliage, remains in suspension and adheres to the foliage for a longer period. To prepare arsenate of lead, dissolve in water three pounds of arsenate of soda and seven pounds of acetate of lead (sugar of lead). Double the strength stated above can be used if desired, without danger of injuring the foliage There are several brands of the manufactured product on the market, which can be used if desired.

SCHEELE'S GREEN (Green Arsenoid.)

Scheele's green (green arsenoid)	1 pound.
Lump Lime (freshly slaked)	2 pounds.
Water	150 gallons.

This arsenical is very similar to Paris green, and has an advantage over it, in that it remains in suspension in water for a much longer time. It is also cheaper in price.

LONDON PURPLE.

London Purple	1 pound.
Lump Lime (freshly slaked)	2 pounds.
Water	150 gallons.

This poison is finely divided, and remains in suspension in water longer than Paris green, and it usually sells at about two-thirds the price of that poison. It is in disfavor because of its variable composition, and the danger of its burning foliage. It is also considered somewhat less effective in killing insects than is Paris green or Scheele's green.

CONTACT INSECTICIDES.

Soap.

The ordinary soft soaps and laundry soaps have long been used for killing insects with soft bodies like plant lice. There are a great many makes of soap, and most all have some insecticidal value. In using make an emulsion with water, usually about one-half to one pound of soap to one gallon of water.

WHALE OIL SOAP.

This is a well-known brand of soap, and is very effective when applied properly. For treating plant lice or similar insects when plants are in foliage, one pound of soap to six or eight gallons of water will suffice. For scale insects, like the San Jose scale, it should be used as strong as a pound and a-half to two pounds to one gallon of water. The stronger applications can only be used in the winter or early spring, when the trees are dormant.

KEROSENE EMULSION.

This, no doubt, is the best general purpose contact insecticide. It is easy to prepare, and the materials composing it are always at hand. The emulsion can be made using the ingredients in the following proportions:

Kerosene	2 gallons.
Common Soap	½ pound.
Water	1 gallon.

Dissolve the soap in hot water, add the kerosene, and emulsify by violent churning. Dilute to the strength required. If Ta-Ka-Nap soap is used, it is not necessary to add hot water. Twelve to fifteen per cent. emulsion is strong enough for killing plant lice.

LIME-SULPHUR WASH.

This wash seems to be the most satisfactory solution for the control of the San Jose scale. It should be applied either in the fall or early spring, while the trees are dormant.

Fresh stone lime	20 pounds.
Flowers or flour of sulphur	15 pounds.
Water	50 gallons.

Boil twenty gallons of water in an iron pot or hog scalder; now add the twenty pounds of lime and fifteen pounds of sulphur, which should have been previously mixed with a little hot water to form a paste. Boil the mixture, stirring occasionally, from thirty minutes to one hour, or until the sulphur is thoroughly dissolved, and produces a clear, amber-colored solution. Then dilute by adding sufficient hot or cold water to make fifty gallons. Strain into the spray barrel and apply warm.

TOBACCO.

Old tobacco stems are often steeped in hot water, a pound of the stems to a gallon or two of water. It is used as a spray or dip against plant lice. Also burning tobacco stems in a greenhouse is helpful in destroying insect pests.

HYDROCYANIC ACID GAS.

This gas has come into use of late years as an important insecticide. Its use in fumigating nursery trees to protect against the San Jose scale has become quite general. It is made by combining the following:

Cyanide of Potassium, 98%	1 ounce.
Sulphuric acid (commercial)	2 ounces.
Water	4 ounces.

This formula will fumigate an enclosure containing one hundred cubic feet; the proper proportion for larger or smaller space can be calculated from this. Place acid in an earthen jar, then add water and cyanide. Be sure to have the room or enclosure air-tight, or nearly so. Keep everything closed for at least thirty minutes or longer. It is a very *deadly gas,* and much care should be exercised in its use.

BI-SULPHIDE OF CARBON.

This liquid is used in destroying insects in stored-grain, and the like. The liquid evaporates very readily. The gas is very deadly to animal life when confined in it for any length of time. In fumigating grain, or other similar material, use two or three pounds of the liquid to one hundred bushels of grain. Place the liquid in shallow pans above the material to be fumigated. Have the enclosure air-tight or nearly so. and fumigate from twelve to twenty-four hours. The gas is exceedingly explosive, therefore, do not allow any *light,* cigar or pipe in the building when fumigating. The gas is heavier than the air.

HOW FUNGI INJURE PLANTS.

A fungus (plural fungi or funguses) is a minute plant without green stem or leaves, and so must get its food from other plants or animals. There are many thousands of different kinds of fungi. Some of the largest are called mushrooms, some of the smaller are called molds and mildews, many live on dead plant or animal substance, and by using them for food produce what we call decay. A great many kinds are able to live on live plants and draw their nourishment from them. These are the ones that cause diseases. This they do by using up the substance needed by the larger plant and thus starving it. or by interfering with its life processes by their presence, or they may kill it by forming poisonous substances within it. The fungi do not bear seeds, but they produce under favorable conditions, multitudes of microscopic reproductive bodies called spores, which serve the purpose of seeds. They are often carried by the wind from plant to plant and being so small that they cannot be seen by the unaided eye, they may spread the disease rapidly without our knowing it.

Bacteria are exceedingly small plants which live much the same as fungi, and cause the most serious diseases of plants and animals.

HOW TO COMBAT FUNGUS DISEASES.

Very few diseases of plants caused by parasites can be cured. Some caused by fungi which live mainly on the outside of the plant and obtain nutriment from inside by means of small suckers, can be killed by the application of poisonous substances to the surface. But most parasitic fungi live inside the plant tissues or only produce their reproductive organs on the outside so that the spores can be carried away easily by wind or other agencies. No devices have yet been perfected by which medicinal substances can be disseminated through plants, as they can be in animals with a circulatory system. So except for such as were mentioned above, and some which may be healed by cutting away the diseased portions, the treatment is mainly preventative, and consists of various methods of preventing diseased plants or part of plants from infecting healthy ones, or of enabling the plant attacked to overcome the disease. Some are more applicable to one disease than another. For the proper treatment for any particular disease the list of diseases of various crops, given later, should be consulted. In any case it is much better to find out what is troubling the crop rather than to apply treatment in a haphazard way. The following are some of the general methods used:

1. When possible grow varieties resistant or immune to disease. Some resistant varieties are mentioned in the following list of diseases of crops. Plant breeders are working along this line at the present time, and disease resistant strains may be developed for most of our important crops. Farmers can do much to aid in this work by watching for resistant individual plants among diseased ones of the same kind in any crops which they may be growing and saving seed from it, or, better, calling the attention of professional plant breeders to the same.

2. Keep plants in vigorous condition by proper cultural methods A check in growth or anything which draws from their food supply often renders them liable to the attacks of parasites.

3. Select seed, cuttings or other propagating stock from healthy plants. Seeds from diseased plants may carry the parasite or may transmit a predisposition to their offspring.

4. Destroy diseased portions of plants.

5. Insects are a very common means of introducing diseases which, without them, would be barred by the unbroken epidermis of the plant. Anything coming in contact with diseased plants and then with healthy ones is liable to transmit disease.

6. Fields, where diseased crops are grown, may carry over winter the infecting material and contaminate the succeeding crop. It is better to follow a diseased crop with some other, not subject to the same disease. This is one of the benefits of rotation of crops. Some fungi may live in the soil for several years.

7. Wild plants of the same family are usually liable to the same diseases as their cultivated relatives.

8. Large fields of one crop, or a lack of diversity of crops in any region, favors the spread of diseases.

9. Wounds in trees or other plants, whether made by pruning or otherwise, favor the entrance of disease germs, and when they cannot be avoided the exposed surfaces should be protected by paint or

some substance to take the place of the broken bark or epidermis. White lead in linseed oil is a good material in general.

10. Weather and soil conditions control the growth of fungi, just as they do with other plants. Alkaline conditions that favor some fungi, as potato scab, can be corrected by proper fertilizers. The application of lime hinders the development of others as the club root of cabbage. Drainage may help in controlling some root diseases.

11. The application of fungicides to prevent the development of parasites is a very important process, and is more fully discussed in the next section.

THE MORE IMPORTANT FUNGICIDES.

A fungicide is some preparation to kill or prevent the development of fungi. Most of the fungicides here described are made of chemicals that can be purchased at drug stores or from agricultural supply houses. Fungicides are applied as gases, as liquids, or in solid form. In solid form they are usually dusted over the plants to be treated by means of a bellows or blower especially prepared for this purpose. The plants or seeds to be treated are dipped in the liquid, or it is sprayed upon them. Spraying is the principal means employed to control plant diseases. The fungicides applied protect the plants in a few cases by killing the fungus causing injury, if it is growing on the outside of the plant. But usually the parasite is inside the leaf or fruit and only produces its spores on the surface. Then the fungicide may destroy these spores before they can be carried to healthy vegetation, or it may prevent the development of spores alighting on the plant to which it has been applied.

BORDEAUX MIXTURE.

Bordeaux mixture is used more than any other substance to prevent plant diseases. It is made of copper sulphate (blue stone) dissolved in water and mixed with stone lime slaked in water. There must be enough lime to combine with all the copper sulphate so that it will not injure foliage, otherwise the proportions may vary considerably for different purposes. The formula usually used is the 5-5-50 formula:

Copper Sulphate	5 pounds.
Lime	5 pounds.
Water	50 gallons.

Dissolve the five pounds of copper sulphate by immersing in a bag hung in the top of a vessel of water for several hours, and dilute to twenty-five gallons of water, a half-barrel can be used to hold it. Slake the lime in a similar vessel and dilute to twenty-five gallons. Pour the two together through a strainer into the sprayer (see Figure

3). The bright blue liquid resulting is Bordeaux mixture. The lime should be kept stirred, as it settles quickly. The copper sulphate will act on iron and some other metals. Brass or wooden vessels should be used for it. The milk of lime and copper sulphate solution should not be mixed while hot or before diluting. They will keep indefinitely before mixed, but the Bordeaux mixture should be used the same day made.

Where several barrels of Bordeaux mixture are to be used, the use of stock solutions will save much time. These are made by dissolving fifty pounds of copper sulphate in fifty gallons of water in one barrel and slaking fifty pounds of lime and diluting it with fifty gallons of water in another barrel. Then, for making Bordeaux mixture take as many gallons as pounds of each substance desired, dilute and mix as before. When proper water supply is at hand, the stock barrels, diluting tubs, etc., can be arranged on an elevated platform so the liquid can be passed from one to the other from spigots, and then run in similar manner through hose into the sprayer thus saving much dipping, etc.

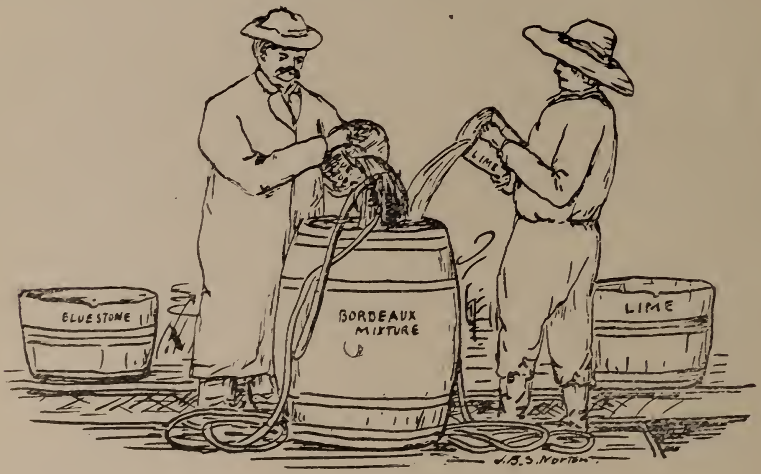

Fig. 3—Making Bordeaux mixture.

The properly prepared Bordeaux mixture should have a bright sky-blue color. If the lime is poor it may have a greenish cast, and is then liable to injure foliage. It can best be tested by dropping a little solution of yellow prussiate of potash into the mixture. If a reddish brown color results, add lime until the test repeated shows no brown color. It is usually better to add more lime than enough to combine with the copper sulphate. One-third pound of Paris green to the barrel can be added, if desired, to kill insects. The Bordeaux mixture is an excellent medium in which to apply all similar insecticides.

Peach Bordeaux mixture for use on peach and plum foliage or other plants liable to injury by the stronger mixture used for most crops, is made in a similar manner by the following formula:

Copper sulphate	3 pounds.
Lime	9 pounds.
Water	50 gallons.

One must be sure the lime is good, as with this excess of lime, the before-mentioned test would not be practicable.

In making Bordeaux mixture various other alkalies have been used instead of lime to combine with the copper sulphate, for example: caustic soda, washing soda, caustic potash, ammonia (in eau celeste), etc. There is no special advantage and some are liable to injure foliage more than the lime Bordeaux mixture and, if made of materials that alone would burn foliage, just enough to combine with the copper sulphate must be used, while with the lime an excess can be used to advantage in many cases.

Bordeaux mixture will not stick to water-repellant surfaces, such as cabbage leaves and asparagus. The addition of hard soap, dissolved in water, four pounds to the barrel, will help to overcome this difficulty.

DUST BORDEAUX MIXTURE.

The dust mixture is sometimes used for the same purposes as the liquid in regions where, on account of hills, etc., it is difficult to haul the liquid. It is not so expensive to make and handle, but is much less effective than the liquid form and must be applied much oftener. It is made as follows, according to W. M. Scott:

Dissolve four pounds of copper sulphate in four gallons of water and slake four pounds of lime in four gallons of water. When cool, pour together, allow it to settle, pour off the liquid, put into a double flour bag and squeeze out as much more water as possible. After drying for a day in the sun it is crushed, screened through an eighty mesh to the inch sieve and thoroughly mixed with sixty pounds of slaked lime dust.

COPPER SULPHATE SOLUTION.

If a very strong copper fungicide is desired for dormant plants, copper sulphate, three pounds to fifty gallons of water, may be used.

COPPER ACETATE.

Dibasic acetate of copper, six ounces to fifty gallons of water, is used where a clear fungicide is desired, as it is readily soluble in water, and Bordeaux mixture may leave stains on fruit and foliage. It is somewhat more injurious to foliage and is not so good a fungicide as Bordeaux mixture.

AMMONIACAL COPPER CARBONATE.

This is used when the stains of Bordeaux mixture are undesirable. It is not so effective as the latter and more liable to injure foliage. It is made as follows:

Copper carbonate	5 ounces.
Strong ammonia (26 degrees Beaume)	2 to 3 pints.
Water	50 gallons.

Make a thin paste of the copper carbonate with water, and after diluting the ammonia with about two gallons of water, add half of it to the carbonate, stir for several minutes, allow it to settle, pour off the solution and add more ammonia water to the undissolved portion, repeat the process until all the carbonate is dissolved, using no more ammonia than is necessary to dissolve it. Then add to the solution the remainder of the fifty gallons of water and it is ready for use.

LIME-SULPHUR WASH.

This preparation, described under insecticides, is valuable as a dormant spray for fungus diseases that can be treated at such times. When it is recommended to use Bordeaux mixture on fruit trees before the buds open this can take its place, but is not so effective and cannot be used on plants in leaf.

POTASSIUM SULPHID.

Potassium sulphid one ounce dissolved in three gallons of water is used for surface mildews. It should be used as soon as made as it deteriorates rapidly.

SULPHUR.

Sulphur is used in the form of "flowers of sulphur" or "flour of sulphur" as a fungicide. The former is usually better for applying in the dust form for mildew, asparagus rust, etc. The flour of sulphur is usually made into a paste with water, and spread on heating pipes in greenhouses, for mildew, etc. The fumes from burned sulphur are used in disinfecting empty greenhouses or other buildings, but are very destructive to live plants.

CORROSIVE SUBLIMATE.

Corrosive sublimate, one part to 1000 parts of water is used as a disinfectant. It is a deadly poison. It is used in this strength in cutting out pear blight.

This is also used to disinfect potatoes for scab, before planting; two ounces to fifteen gallons of water is used.

FORMALIN.

The commercial formalin (40%) is used one pint to fifty gallons of water for grain smut and one-half pint to fifteen gallons of water for disinfecting potatoes affected with scab. It is poisonous, but not so dangerous to handle as the corrosive sublimate. Formalin is one of the best disinfectants for all purposes.

PROPRIETARY PREPARATIONS.

Many proprietary preparations, for controlling insects and plant diseases, are on the market. Some of them are very good. But, as a rule, they cost more than those which can be made by the user as recommended in this bulletin. Any claims made for a material as a general cure-all for any kind of plant disease or insects are apt to be fraudulent. There are hundreds of different kinds of parasites with very different life histories and requiring very different treatment, according to the crop attacked.

IS THERE DANGER IN THE USE OF FUNGICIDES AND INSECTICIDES?

Some have thought the application of copper compounds and arsenical mixtures to fruits and vegetables, intended for food, would make them poisonous to man. It has been shown that one would have to eat 300 to 500 pounds per day of grapes sprayed with Bordeaux mixture to experience ill effects from the copper, and that even if all the Paris green sprayed on apples for codling moth should remain there, one would have to eat eight to ten barrels of the fruit to be injured by the arsenic.

Potatoes, treated with corrosive sublimate for scab, contain enough poison to be injurious to animals eating them.

If the chemicals used are applied too strong, or are improperly made up, injury may result to foliage of plants sprayed. *Careful attention should be given* to all the details given about preparing and using fungicides and insecticides. An effort has been made to cut out all unnecessary matter from the directions given in this bulletin, and to make it as brief and simple as possible.

Even with the best of care the leaves of some trees will be injured occasionally by sprays, but the injury will usually not compare with the good results obtained. Trees and other plants, which have a limited blooming period, should not be sprayed when in bloom.

Most of the chemicals used in protecting plants from insects and diseases are poisons, if taken internally, and should be handled and labeled as such. With reasonable care there is no danger from their use.

SPRAYING AND SPRAYING OUTFITS.

The continued increase in spraying crops for the control of insects and diseases, has created a large demand for spraying apparatus of improved types. Manufacturers of these articles have been active in perfecting their different patents to meet the demand. So that today the prospective purchaser has a variety of styles of spraying outfits from which to select.

The question is frequently asked "What is the best pump to buy?" As a matter of fact, there is no "best" pump on the market. The conditions under which spraying is done are so varied that only general recommendations can be made, and each individual will have to select that which his judgment dictates is best adapted to his conditions. A common error, is to purchase a pump of too small a capacity because it is cheaper. A smaller, cheaper pump usually means less accomplished in a day with the same labor and usually a poorer class of work. Also it is sometimes of much importance to complete the desired amount of spraying in as short a time as possible after it is begun. To do this a pump of large capacity is necessary.

While no specific laws can be laid down in purchasing outfits, yet some fundamental facts in regard to such apparatus may aid in deciding on an outfit.

BUCKET PUMPS.

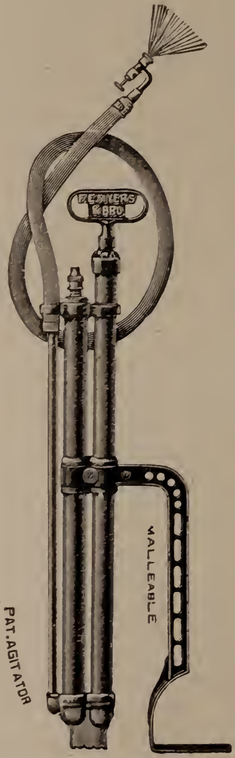

Fig. 4—A bucket pump.

Where spraying is to be done on a very small scale, that is, treating one or two trees or bushes, or other growing plants around the home, a bucket sprayer, as shown in the accompanying cut, Figure 4, will serve the purpose. They are usually made to set in a bucket, with a clamp attached to the side of the bucket and a foot piece extending to the ground, by which the foot can hold it rigid. These pumps are usually very durable, and handy for certain kinds of work.

KNAPSACK AND OTHER HAND SPRAYERS.

This pump, as shown in Figure 5, is designed for similar work as above, except on a more extended plan. Such pumps are used in spraying low-growing plants, especially if their habit of growth and surroundings will not permit the use of large apparatus. A true knapsack sprayer consists of a small tank, containing from three to five gallons of solution, in which is fitted a small pump. The whole apparatus is carried on the back, the pump being worked by the hand, through a lever which extends down in easy reach. It is sometimes

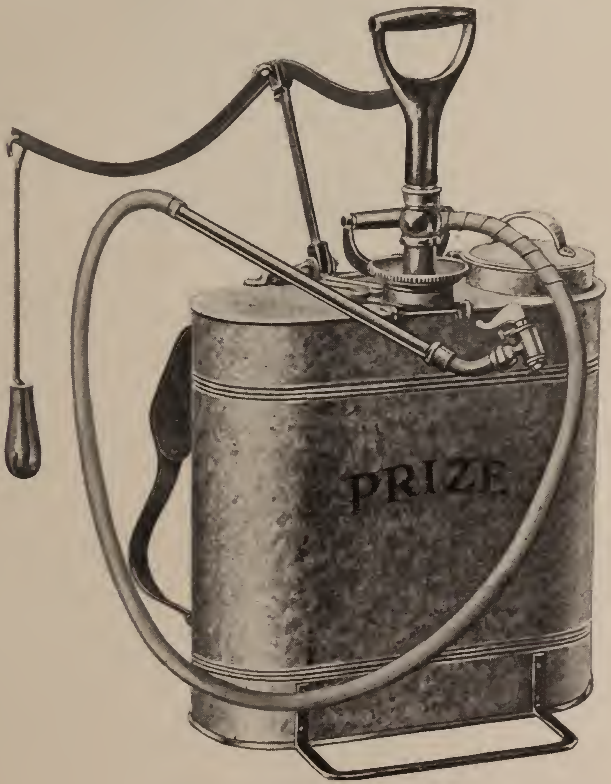

Fig. 5—A knapsack sprayer.

used by greenhouse men, who find it convenient for sprinkling, the sprayer being on the back of the operator permits him to pass along the aisles freely, using one hand to operate the pump and the other for spraying. The feature of carrying the pump on the back is not a favorable one to the sprayman, as the leaking and waste sometimes makes it very uncomfortable. We believe that this particular form of pump is fast going out of use, and is being supplemented by pumps as shown in Figure 6. This form can be used for the same purposes and is considered by many the more handy and convenient of the two. They are known as compressed air pumps. The tank holds about three to four gallons of liquid and a compressed air chamber. After filling up the tank, a sufficient amount of air can be pumped in before you start spraying, to spray out most of the liquid. They are used in spraying low-growing plants, such as cantaloupes. Many of these pumps are in use all over the State.

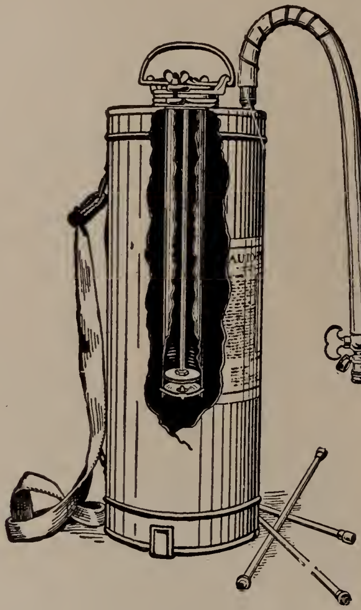

Fig. 6—Compressed air hand sprayer.

BARREL PUMPS.

There is perhaps a greater variety of this size of pump on the market than any other, due to the fact that they are the most common size used for general spraying. It would be impracticable to explain all the different types and makes in this discussion. Figures 7 and 8 illustrate the size and form of the pumps. Whatever the size selected the pump should be strong, simple in mechanism, and capable of maintaining a constant high pressure to deliver a large amount of liquid with force. It should be made of material that will not easily corrode or rust from contact with the various insecticides and fungicides. Especially should the working parts be of brass and, likewise, it is

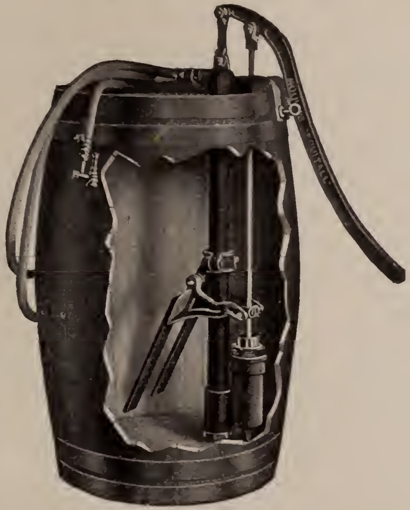

Fig. 7—A good type of barrel spray pump.

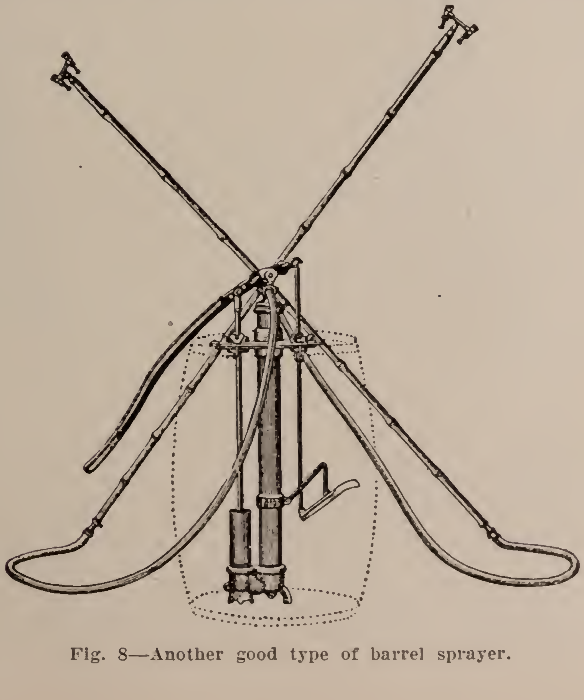

Fig. 8—Another good type of barrel sprayer.

important to have the packing in a convenient place where it can be removed without much trouble, and for this reason pumps with solid plungers are more desirable.

VALVES. The structure of the valves in a pump is a very important feature. They should be made preferably of brass and, of necessity, perfect fitting. When these parts are made of leather the pump may work for a time, but the material soon becomes stiff and hard and requires frequent replacing.

AGITATORS. An agitator is a very necessary adjunct to all classes of spray pumps, for success in spraying will sometimes depend on keeping the liquid thoroughly stirred up. While most pumps are fitted with some form of automatic agitator, it is well to look into the ability of any particular apparatus for keeping the solution well mixed.

AIR CHAMBERS. The air chamber should have sufficient capacity to insure a steady spray. It should be combined with the other parts of the pump as shown in Figures 7 and 8. The position and size of the air chamber should be carefully examined.

GENERAL STYLE. While the details of construction of the many pumps vary, these general principles should be observed: Buy the pump which is compact and simple in construction. Do not have too much of the pump above the surface of the barrel, and have it easy to get at in the barrel, or, better, easy to remove from the barrel. The clamps used by some manufacturers allowing you to transfer a pump from barrel to barrel without unscrewing bolts and avoiding other troubles is desirable. Also have all points of attachment of the hose cut with threads of standard size. The handles should be made of malleable iron as they are not then so easily broken as if made of cast iron. The illustrations cited will give the reader some idea of types of barrel pumps on the market. A good barrel pump with fixtures can be bought for from $15.00 to $20.00.

HORIZONTAL DOUBLE-ACTING PUMPS.

This class of pumps is used by the more extensive fruit growers. They are more powerful, so that four leads of hose can be attached, if desired. They, however, work very easily by hand. The pump which is double-acting is connected with the tank containing the spraying mixture by means of a section of hose which is shown in Figure 9 Such a pump can be secured for about $30.00.

POWER SPRAYERS.

The increased planting of orchard fruits during the last few years has given rise to many quite extensive orchards, which has brought about a demand for power sprayers in order to facilitate the work of spraying these large orchards in a short space of time. The labor problem in the United States has also contributed towards increasing the demand for this machinery. The question of the most economical pump or apparatus is debatable, and, no doubt, may be in favor of the barrel pump, if the labor problem does not enter into it seriously. However, it seems that the power sprayers are steadily coming in favor with the commercial orchardists.

GEARED SPRAYERS. This type of sprayer has been on the market for some time. It usually consists of a mechanical arrangement connecting the pump with the wheels of the wagon, cart or specially constructed spray wagon. When arranged on a simple barrel pump for spraying low growing crops, such as potatoes, where the wheels can be in continual motion, except at the end of rows, they have proved fairly successful; but when fitted with larger pumps to do orchard spraying, seldom can sufficient force be maintained to throw a steady spray without the machine is in motion all the time, and it is impossible to do thorough spraying under these circumstances. Manufacturers have realized this condition, and, for the past few

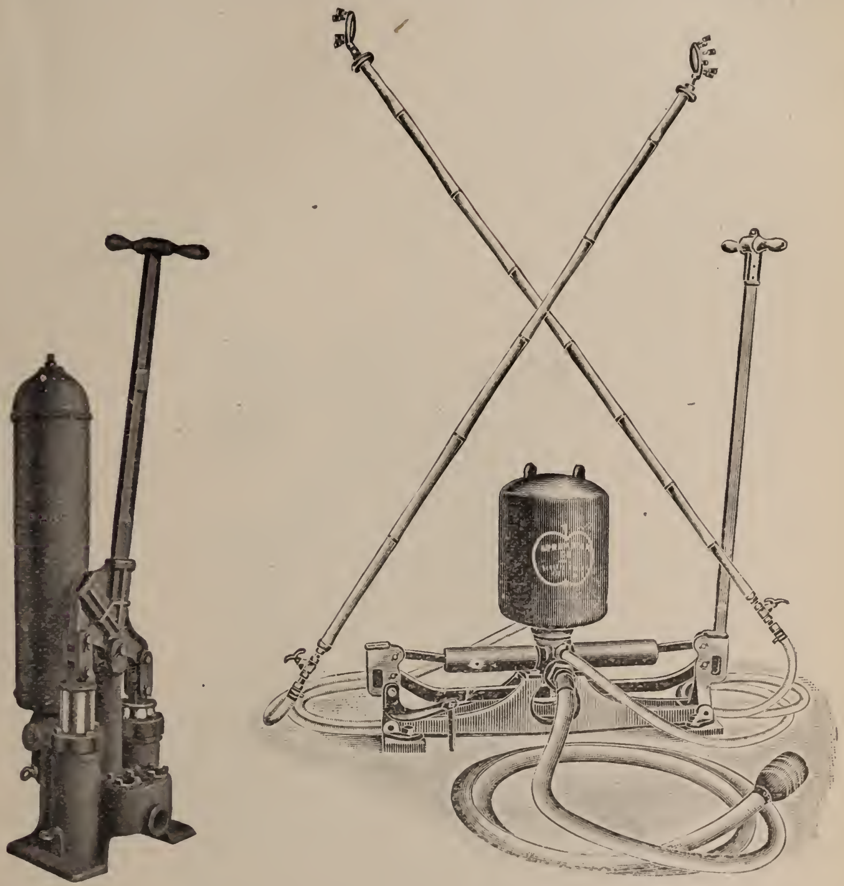

Fig. 9—Two types of double-acting spray pumps.

years have been expending their energy toward perfecting other forms of power sprayers.

STEAM AND GASOLINE OUTFITS. The majority of the power outfits on the market today employ either steam, made in a small two or three horse-power boiler, or use the gasoline engine, and, no doubt, the larger number employ the latter. The objection to the steam boiler, with the accompanying apparatus, being its weight. However, the gasoline sprayers have their drawback in trouble arising in the working of the engine, etc., necessitating delays in the operation; the objection of weight also applies to a certain extent with many gasoline rigs. Usually one and one-half to two horsepower engines are used. The continued perfecting of these engines will be of much importance in the success of such outfits. One advantage in the use of such an engine in spraying is that it can be detached from the pump and used on the farm for various other purposes. Figure 10 illustrates a gasoline outfit.

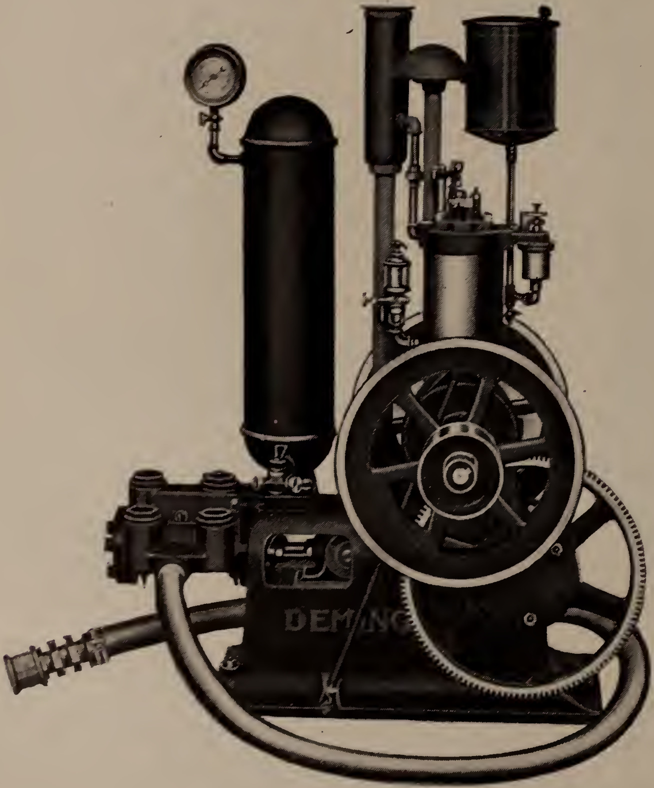

Fig. 10—Gasoline spraying engine.

GAS SPRAYERS. This form of power sprayer is of comparatively recent introduction. The machines are operated by liquified carbonic acid gas. There is no doubt that a decided step of progress is manifested in these machines, for they are very simple in construction and give apparent satisfaction in spraying, but the expense of maintaining the machine seems to be a great drawback, especially when, after being used for some time, leaks occur in the apparatus, thus wasting the carbonic acid gas, which is quite expensive. These obstacles may be overcome in the future, but, even then, the expense of the gas as compared with the gasoline used in the gasoline engine will, no doubt, prevent general adoption. To those anticipating securing a power sprayer we advise a careful study of the kinds and makes on the market. Figure 11 shows a gas sprayer.

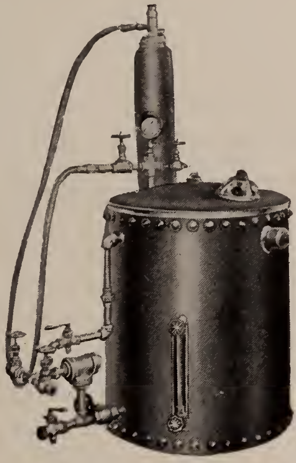

Fig. 11—A gas sprayer.

SPRAY PUMP ACCESSORIES.

HOSE. It is important in spraying to have plenty of good hose. That is to say each lead of the hose from the pump should allow the sprayman to surround the tree without moving the pump. The thoroughness of spraying often depends on this one requisite. Have each lead from 20 to 25 feet long. It is not necessary to say that the best quality of one-half inch hose should be used in this work.

EXTENSION ROD. It is generally convenient to have a hose attached to an extension rod of either iron or bamboo with brass tube. They should be from four to ten feet in length, according to the character and size of the trees to be sprayed. A blacksmith can easily make one from one-quarter to one-half inch gas pipe. A six-foot rod is used more generally. (See Figure 12.)

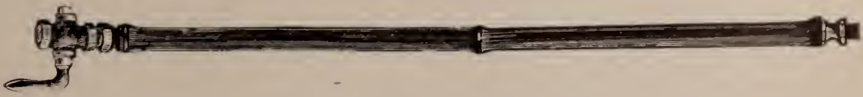

Fig. 12—Bamboo extension rod.

STOP-COCK. Be careful to have a leakless stop-cock at the end of the hose attached to the extension rod. This will avoid wasting material when moving from tree to tree and allows the liquid to be shut off from the pump when the nozzle is stopped up.

NOZZLES. In general there are two classes of nozzles, one giving a fanlike spray and the other a conical spray. Figures 13, 14 and 15 show these types respectively. The many pump manufacturers make these different nozzles and the selection is again left to the purchaser. The nozzles are often combined, that is to say, we have single or double Vermorel or two Seneca nozzles can be attached to one hose. The number used depends on the force of the pump employed.

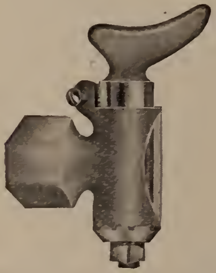

Fig. 13—Nozzle giving a fan-shaped spray.

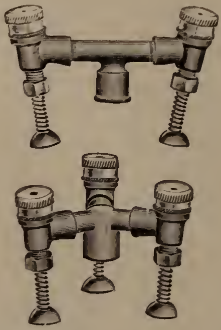

Fig. 14—Double and triple vermorel nozzles, producing conical spray.

The essentials of a nozzle are that it should throw a fine, misty spray a long distance and not be easily clogged.

STRAINER. All mixtures should be carefully strained into the spray barrel or tank to insure uninterrupted service of pump and nozzle.

The most durable, no doubt, is the brass wire strainer. It should be about 18 to 20 mesh.

ROW SPRAYERS. This is a very convenient device that can be connected with the barrel sprayer and attached to a cart or wagon and serve to spray low-growing crops in rows to great advantage. Figure 17 shows this arrangement.

TANKS. In the use of barrel pumps the barrel serves as the tank for holding the solution. In using some of the pumps on the market they will permit of taking one or two barrels of solution along in the wagon, as the pump can be easily transferred from one barrel to another. In the case of the horizontal double-acting pumps or power sprayers it is necessary to have a regular tank, the size varying according to the requirements. In case of a long haul from the orchard to the source of supply, of course, it is economical to have as large a tank as convenient to transport in the orchard. The accompanying figure, 18, shows the usual form of a tank. Generally such tanks are made to fit the bolsters of the wagon, which is the most handy way of hauling the same. In using horizontal pumps they can be fitted on top the tank; in power sprayers the power in the form of either gas or air tube or engine can be located in another convenient place on the wagon.

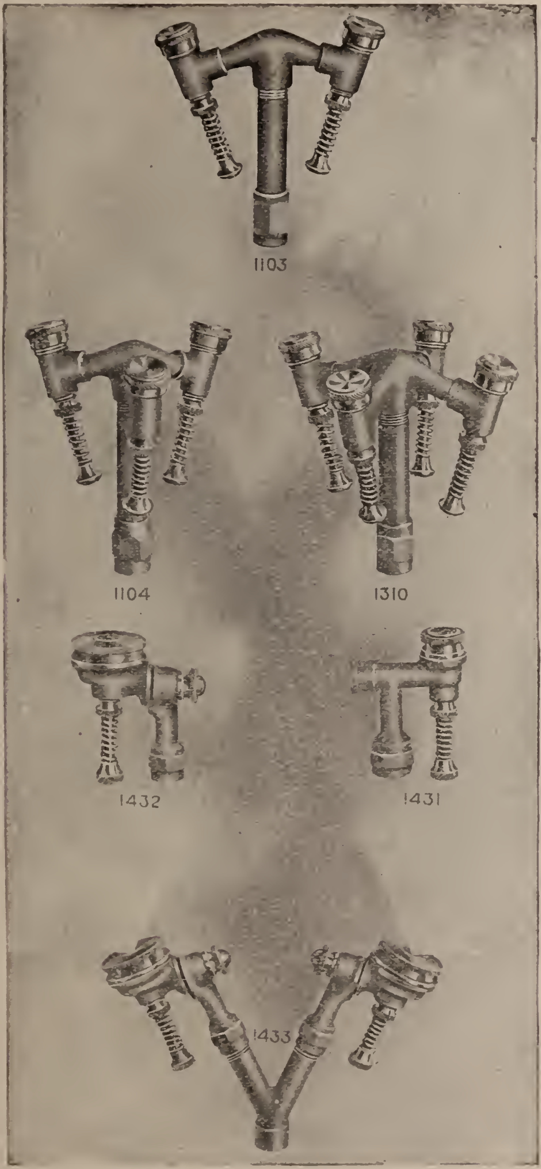

Fig. 15—Various types of nozzles.

RACKS. In the treatment of large trees, either fruit or shade, it is often very difficult to reach the terminal branches, even with the six-foot extension rods. In such cases the use of a rack built on the spray wagon, with a platform on the top, on which the spraymen can stand, will greatly facilitate the work.

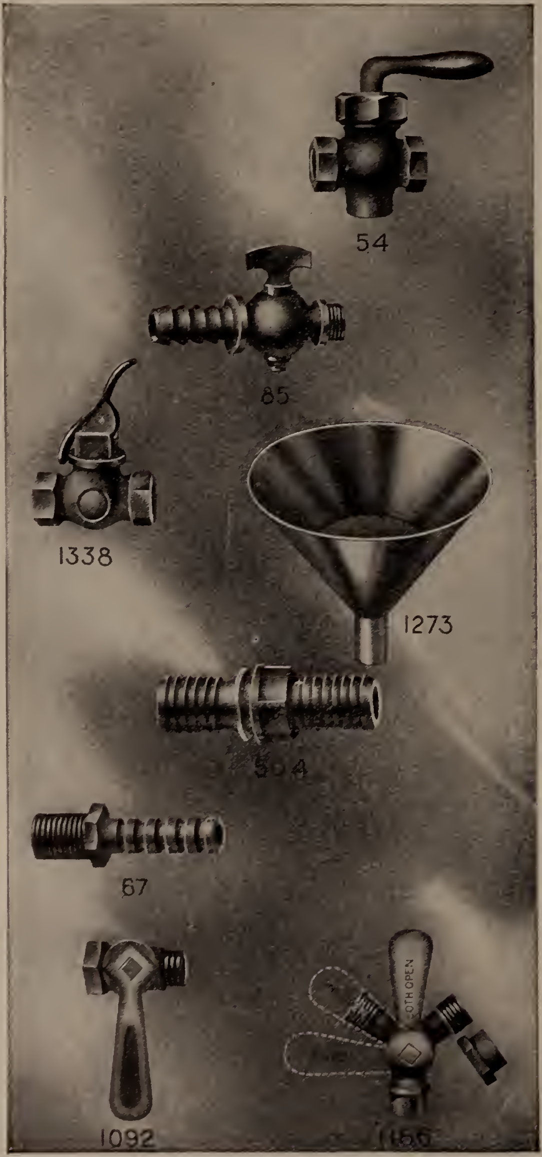

Fig. 16—Spray pump accessories.

SOME TROUBLES IN SPRAYING.

It often happens that a pump fails to work. There are many minor troubles which may occur. First, a little sediment may become lodged under one of the valves, causing it to leak. If lime is being used in the spray solution it is apt to accumulate over the strainer at the bottom of the pump. Of course, these troubles can be easily remedied by cleaning the particular parts. Repacking the pump is necessary at times, as the packing becomes worn and, causing a leak by the plunger, the force of the pump is lost.

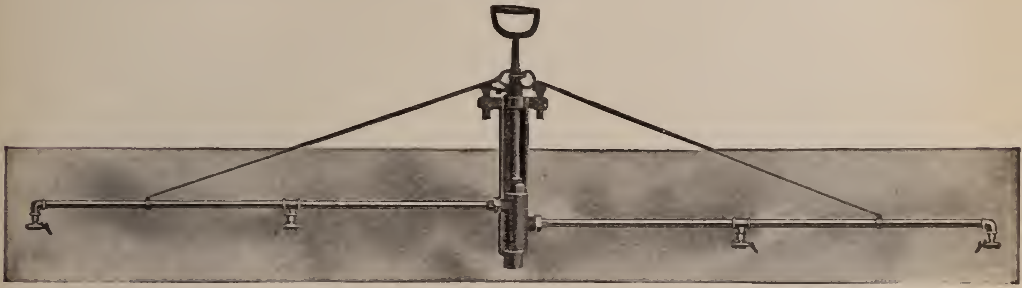

Fig. 17—Row sprayer attachment.

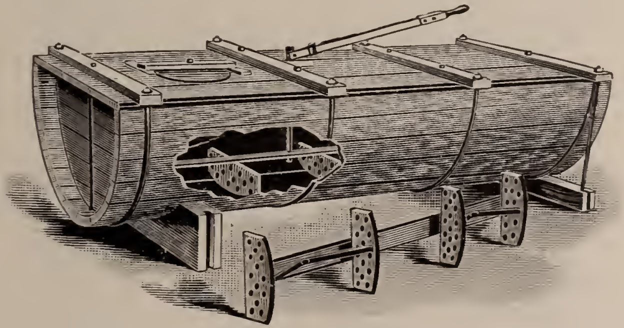

Fig. 18—Tank for carrying spraying mixtures.

CARE OF SPRAYING APPARATUS.

The life of a pump or other spraying apparatus depends largely upon the care given it both at work and at rest. During the spraying, pumps, hose, etc., should be washed out thoroughly every night after finishing the day's work, even if the pump is being used every day. When the apparatus is to stand for several days or months unused, it should be given a more thorough cleaning by washing off the corrosive mixtures and freeing the valves and other parts of all sediment, which might otherwise dry and become incrusted on the parts. If there is a long period between sprayings, it would pay to remove the pump from the tank, taking it apart and oiling all the parts to prevent rust.

Likewise, the hose should be handled with care. It should be hung up in such a manner as to allow the water to run out. The fault of using too short a hose has a decided effect upon the piece in hand. If it is somewhat short, it is often bent too much or stretched around angles or corners, causing more or less injury at times. The cleaning of the hose and nozzles is equally important to their life in preventing vexatious stoppage in the operation.

APPLICATION OF DRY MATERIALS.

At times it seems desirable to apply an insecticide or fungicide in its dry state, as in dust spraying of Bordeaux mixture or Paris green. Many styles of small machines for this purpose are on the market. The handiest of the inexpensive forms is that in which a receptacle for containing powder is so attached to a small hand bellows that the dust is thrown in any desired direction. Sometimes guano sacks are used in applying the dust to a low-growing plant by jarring the material through the small holes in the sack. Figure 19 shows a commercial powder gun.

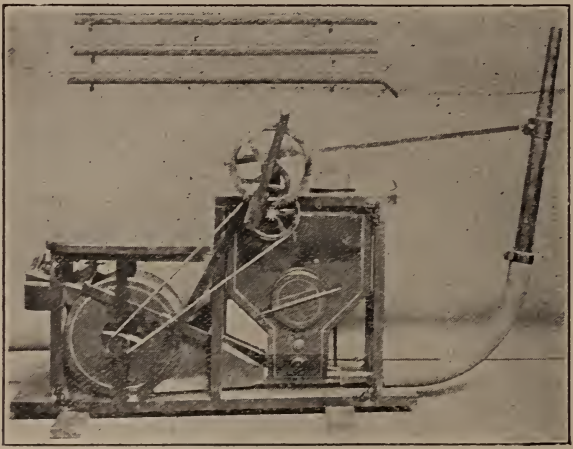

Fig. 19—Apparatus for applying dust spray on large scale.

GENERAL RULES FOR SPRAYING.

In the observance of the general rules for spraying, the first requisite is to know exactly what the spraying is intended to control or check. Ascertain the proper time of the year to make the application. Make your solution carefully, according to the formula given. Secure a good serviceable pump and necessary apparatus and commence spraying with the intention of doing a thorough job. So much of the spraying is only half done. Remember, in spraying trees, all parts must be hit. The length of the hose will facilitate the work. In the use of some solutions in particular, and all solutions in general, it is well for the spraymen to be provided with rubber or oilskin coat, hat and gloves, as this will prevent any undue irritation from the work. Much can be accomplished by management; in having things to work closely together, that is, in arranging the water supply and place of making up the spray solutions at the same place, if possible, and, if circumstances will permit, to have both where the spraying is to be conducted. There is much in business management on the farm.

THE USE OF A PUMP ON A FARM.

Not only can a spray pump be used in applying all insecticides and fungicides, in preventing the distribution of injurious insects and plant diseases on most crops, but it can also be used in other ways. The pump can be used in whitewashing outbuildings. By straining the whitewash into the spray barrel and applying to the barn through the nozzle, a fairly good job of whitewashing can be done in a comparatively short space of time; likewise, the pump can be used in disinfecting chicken houses, stables, etc., by spraying the interior walls. Thus the pump should be considered a necessary piece of machinery on the farm.

SPRAY PUMP MANUFACTURERS.

It is not for us to call attention to any particular make or size of pump for the purpose of advertising it, for we represent no manufacturer. We consider it our duty to the orchardists and farmers of the state to give our opinion, when asked, from our practical experience in the use of the various spray pumps. As to the general type and even make of pump that will be more serviceable, our position being with pumps as with insecticides: When we have proven their use and practicability by experience, we are ready to endorse them.

The catalogues of most firms are well illustrated, and it is wise for those anticipating purchasing a pump to secure these from many firms and select the one suited to his work. To this end the following list of manufacturers and dealers in pumps and supplies is given:

Griffith & Turner Co., Baltimore, Md.
Gould's Mfg. Co., Seneca Falls, N. Y.
The Deming Co., Salem, O.
Morril & Morley, Benton Harbor, Mich.
Field Force Pump Co., Elmira, N. Y.
Myers Pump Co., Ashland, O.
Geo. H. Stahl, Quincy, Ill.
Spray Motor Co., Buffalo, N. Y.
L. H. Orndorff, 203 7th street, Washington, D. C.
F. W. Bolgiano & Co., 935 B stret, Washington, D. C.

WHAT'S THE USE OF SPRAYING?

There is no one thing that concerns fruit growers which is more strongly advocated by some and more severely criticised by others than spraying of fruits. Not infrequently do we hear one voice his opinion regarding the matter as follows: "It don't pay; I have tried it! There is nothing in it." The incentive to such remarks is generally the result of an unsuccessful attempt at spraying, and the whole process is branded as a failure; but in these it is generally the result of carelessness or of a mistaken understanding of the proper methods of making and handling the spray mixtures.

Any quantity of evidence could be given in citing actual tests from carefully conducted experiments proving the great increase in yield and quality of various fruits and truck crops by judicious treatment in the form of spraying. Some of them may be given as follows: Recent work at the Geneva Experiment Station, New York, has shown conclusively, after several years' trial, the decided gain in spraying potatoes for blight and bugs. As an example, giving figures on a total area of 61 and one-sixth acres sprayed in the six experiments in the different parts of the State of New York, there was a total increase of 3.440 bushels in yield, or an average of 61.24 bushels per acre. At 50 cents per bushel the increase was worth $1,873.00. Subtracting from this amount the total expenses of the spraying, $296.49, there is a remainder of $1,576.51, which the total net profit. This is at the rate of $25.77 per acre. Does this pay?

Again, actual tests in the orchard of this Experiment Station in spraying for the codling moth, the insect which causes the wormy apples, showed the following data: On the trees which were sprayed twice during one season, once when the blossoms fell and again about the first of July, we secured 90 perfect apples and 10 wormy ones in every 100. On unsprayed trees 10 perfect apples per 100. Did these sprayings pay?

Similar tests at the Delaware Experiment Station, conducted recently, gave like results. Workers at Cornell University, and at the Missouri, and Illinois Experiment Stations have shown 40 per cent. improvement in spraying the foliage of plum, peach and apple in early spring to control plum curculio. Professor Corbett found in conducting tests of spraying for apple scab, in West Virginia, that the results showed a gain of 80 per cent. on treated trees.

Three years' test of spraying potatoes at this Experiment Station showed an average increase of 52 per cent. on the sprayed fields, spraying three or four times from June to September. On late varieties, when no blight was present, experiments in New York show a net profit of $11.00 per acre when potatoes were only twenty-five cents per bushel. It cost there four to six dollars per acre to give five applications of the spray per season to potatoes. This includes labor for man and team and wear on sprayer, labor being estimated at seventeen and one-half cents per hour, which is more than is usual in this State. Here we could usually spray at a cost of less than one dollar per acre for each spraying. Labor is the principal expense after the spraying outfit is secured, as the materials cost comparatively little.

One way in which persons not altogether familiar with the process of spraying are very apt to become discouraged and dissatisfied with the results obtained is they are too likely to think that one remedy ought to be a cure-all rather than a preventative for one thing, and because such does not prove to be the case in one or two trials, they are led to wrong conclusions and set the job aside as a failure. Spraying is merely one of the sanitary measures that necessarily go with successful fruit raising; it is a preventative, rather than a curative. Bordeaux mixture is not an efficient remedy against the attacks of insects, neither will Paris green successfully prevent apple scab or bitter rot of apples, but a combination of the two remedies, if properly handled, will prove an efficient barrier against a variety of troubles. Spraying is an expensive and tedious process, and it is not worth doing at all unless it is done well and done at the right time. That does not mean that it is necessary to spray eight or ten times during the season in order to get results. Three thorough applications, made at the proper time, ought to insure a good percentage of most crops in an ordinary season.

We do not believe that spraying is the most essential requisite to successful fruit culture. We do not even believe that it is the only means that should be employed to hold in check the numerous insect and fungus pests of cultivated crops. But we do believe that, in this age of San Jose and other scale insects, codling moth, peach tree borer, apple scab, apple canker and blight, brown rot and other injurious insects and diseases, he is wise who insures his fruit and trees against the ravages of these pests by a judicious use of the spray pump. Every one who owns a fruit tree of any kind should spray that tree or cut it down. This obligation should rest not alone upon those who are in the business of fruit growing. It should apply as well to the farmer who grows fruit only for family use, and to the dweller in towns or cities who grows only a few trees on the back yard or on a vacant lot. It should apply with particular force to the last two classes. The progressive horticulturist knows that the health, even the life of his trees, the quality of his fruit, and, hence, the degree of his success often times depends on the right use of the spray pump.

The time may have been when all that was necessary to successful fruit growing was to plant and let nature do the rest. That time, if it ever existed, is past. To make them pay, modern orchards must be cared for and managed like any other business. Spraying is a necessary part of correct management and the best kind of insurance against failure from insects and disease.

THE PRINCIPAL PLANT DISEASES AND INSECTS.

How to Recognize Them and How to Control Them.

In this list the various crops or plants are arranged alphabetically and the most common or injurious insects and diseases are given for each. Such brief descriptive notes are given for each as are necessary to enable the reader to distinguish between the different kinds of injury found on any one crop. A brief mention of the best treatment is given. For more complete instructions about any insecticide or fungicide refer to the first part of this bulletin. For more complete descriptions of insects see Bulletin 101, of this Experiment Station.

ALFALFA.

DISEASES.

LEAF-SPOT *(Pseudopeziza medicaginis).* The leaves turn yellow and are covered with small dark-colored spots. Treatment: Mow and rake off the diseased hay when disease appears. Frequent cuttings keep down the disease.

DODDER *(Cuscuta species).* A slender, yellow, leafless vine grows in masses on the plants. Controlled by cutting out the affected spots in the field before the dodder seeds. Use clean seed.

INSECTS.

There is no particular pest on alfalfa in this state, save the injury done at times to the foliage of the plant by little jassids and sometimes grasshoppers. In practice there are no means to successfully combat either pest.

APPLE.

DISEASES.

SCAB *(Venturia inaequalis).* Dark, scabby spots, usually with a faint white line around them on the surface of the apple (Fig. 20); not extending into the flesh, but may cause the fruit to crack; also causes olive-colored spots on leaf. Spray with Bordeaux mixture

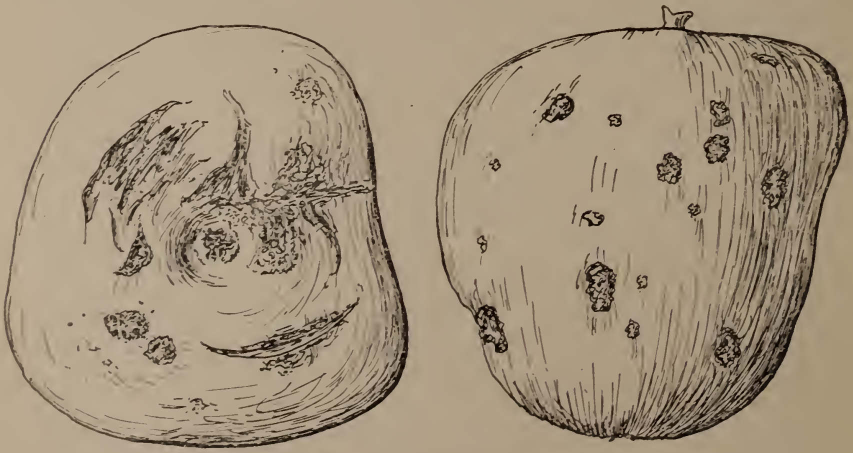

Fig. 20—Apple scab.

just before buds open and again after the petals fall. Better results will be obtained by spraying again after ten days, or if rainy, giving a fourth or fifth application at ten-day intervals. Some varieties are resistant.

Bitter-rot *(Glomerella rufomaculans).* Slightly sunken dark-brown rotten areas on fruit and extending deeply into the flesh; bitter tasting. The surface of the spots show concentric rings and may increase in size until the whole apple is covered. Controlled by five or six applications of Bordeaux mixture at two-week intervals beginning about June 15th. Also gather and destroy the rotten fruit and cut out and burn limb cankers.

Fruit-speck. Late in the season apples may become specked with small, black, sunken spots, due to the attacks of some fungus through the lenticels on the surface. Its further spread is prevented by cold storage.

Water core, causing hard, watery spots in the apple flesh, and Internal Brown Spot are diseases not yet well understood.

Flyspeck *(Leptothyrium pomi)* and other diseases caused by small fungi growing on the fruit surface and often seriously discoloring it can be prevented by spraying with Bordeaux mixture when the fruit is one-fourth grown.

Powdery Mildew *(Sphaerotheca mali)* causes a whitish, mildewed appearance on the leaves and young twigs especially in the nursery, where it can be treated with frequent sprayings with Bordeaux mixture or ammoniacal copper carbonate, and thus prevent the great reduction in growth occasioned by the disease.

Rust *(Gymnosporangium sp.)* causes bright, yellow-colored, thickened spots, one-fourth inch wide on the leaves. One stage of the fungus is the cedar apples on the red cedar. Spraying with Bordeaux mixture after the blossoms fall is a partial preventive. Removal of cedar trees near the orchard will also help. Some varieties are especially susceptible to the disease.

The apple is also affected with a *brown rot* similar to that of the plum and peach. It usually starts from injuries made by birds or insects, etc. Other *rots* attack the ripe fruit and are best prevented by care in handling and by cold storage. Rotten and specked fruit should be separated from the better grades.

Crown-gall. Rough knots thicker than the root and with or without an unnatural abundance of fibrous roots indicate this disease. The hard woody gall is not so injurious as the soft form, but it is better to only plant trees with perfect roots. For control in nursery see bulletin 100, Bureau Plant Industry, U. S. Department of Agriculture.

Hairy-root is a somewhat similar disease indicated by an abundance of stiff, wiry, fibrous roots. Trees so injured should not be planted.

Root-rot. Various fungi or soil conditions cause the death and decay of roots of apple and other trees. Such trees show much reduced growth and small yellow leaves. They had better be dug up and burned.

Wood-rot fungi attack the heart wood, especially of trees poorly cared for. Their entrance through wood surface exposed by pruning, cankers, *wind break,* etc., can be prevented by painting the exposed surface as indicated under canker.

Black-rot *(Sphaeropsis malorum).* Similar to bitter rot, darker colored, not extending so deeply into the flesh. Treatment same as for scab. See also canker and leaf-spot.

Blight *(Bacillus amylovorus).* See pear diseases.

Leaf-blight or Leaf-spot *(Phyllosticta and Sphaeropsis malorum).* Several fungi cause nearly circular brownish spots one-fourth inch or less across on apple leaves. Spraying as for bitter rot or scab is effective against them.

Canker *(Sphaeropsis malorum, Bacillus amylovorus, etc.).* Somewhat sunken, roughened, ulcerlike areas in bark, which is entirely or partially killed, exposing the wood to evaporation. Trim out the injured portion and paint with white lead in linseed oil. In spraying with Bordeaux mixture spray the body of the tree. Cankers may also start from *Sunscald,* caused by drying on the southside of tree in winter or from *frost cracks.*

Collar-rot, the common decay of bark at base of tree can be treated as canker.

Insects.

Woolly aphis *(Schizoneura lanigera).* A plant louse; larvæ appear as a cottony mass; does injury by sucking; attacks either root or branches. Secure clean nursery stock; apply a handful of tobacco dust when planting trees. Apply tobacco dust to roots later. When on branches spray with 15 per cent. kerosene emulsion.

Borers, round-headed *(Saperda candida),* flat-headed *(Chrysobothris femorata)* appear as larvæ (white worm); attack trunk by boring and eating. Remove borers in October and again in March or April.

Fruit-tree bark beetle *(Scolytus rugulosus).* Small, black beetle; attacks trunk and branches by boring "shot holes" into wood. (Figures 21, 22, 23.) Keep all brush cut out of orchard. Destroy infested parts.

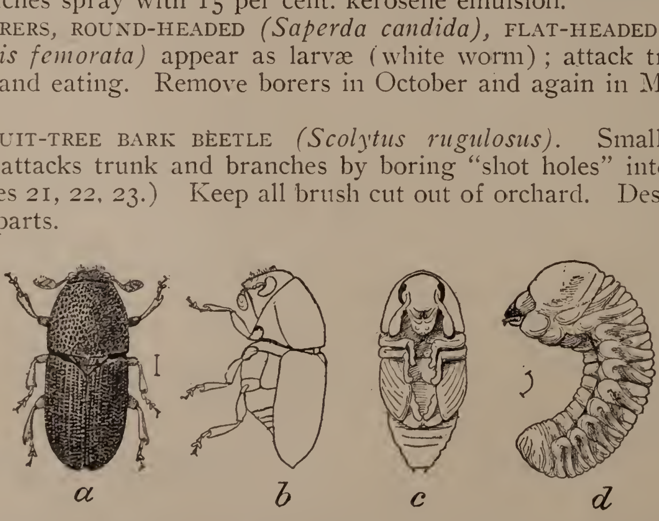

Fig. 21—Fruit-Tree Bark Beetle: a, adult beetle; c, pupa; d, larva. (After Chittenden, U. S. Dept. Agriculture.)

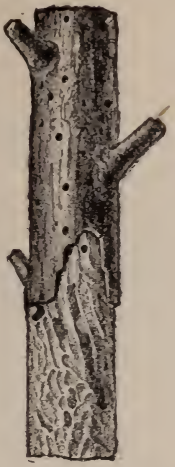

Fig. 22—Showing galleries of Fruit-Tree Bark Beetle, under bark of twig. (After Chittenden, U. S. Dept. Agriculture.)

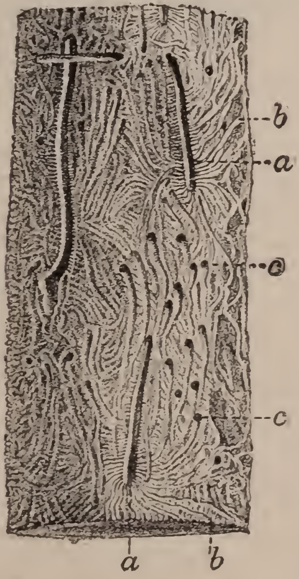

Fig. 23—Showing work of Fruit-Tree Bark Beetle, on a twig of apple. (After Chittenden, U. S. Dept. Agriculture.)

San Jose scale *(Aspidiotus perniciosus).* Small, roundish scale insect; injury by sucking, badly infested tree shows ash-gray appearance. Apply lime-sulphur wash just before buds open in spring.

Oyster-shell scale *(Lepidosaphes ulmi).* Small scale, dark in color, shape of an oyster; injury by sucking. Apply lime-sulphur wash in early spring, or 15 per cent. kerosene emulsion about the middle of May.

SCURFY SCALE *(Chionaspis furfura)*. Small, whitish scale, triangular or pear shape; injury done by sucking. (Figure 24.) Apply lime-sulphur wash in early spring, or 15 per cent. kerosene emulsion about middle of May.

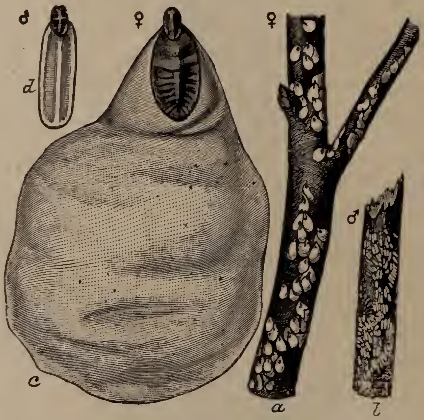

Fig. 24—The Scurfy Scale; a, c, females; b, d, males; a, b, natural size; c, d, enlarged. (After Howard, U. S. Dept. Agriculture.)

APPLE APHIS *(Aphis sp.)*. Small, green plant lice; suck juices from leaves in early spring. Apply 15 per cent. kerosene emulsion.

APPLE-TREE TENT-CATERPILLAR *(Malacosoma americana)*. Hairy caterpillar, eats foliage of trees. Apply arsenical or destroy tents at night with torch or by cutting out.

FALL WEBWORM *(Hyphantria cunea)*. Small caterpillar; eats foliage of tree. (Figure 25.) Apply arsenical or destroy web.

CODLING MOTH *(Carpocapsa pomonella)*. Small larva; injures apple by eating into it, causing "wormy" fruit. Spray with arsenical when blossoms fall. Repeat spraying in about ten days. Repeat spraying about 20th of July.

PLUM CURCULIO *(Conotrachelus nenuphar)*. Small beetle; eats foliage in early spring. Later females do injury by depositing eggs in fruit. Spray foliage with arsenical; jar trees with a sheet under same in early morning. Repeat until beetles diminish in number.

APRICOT.

Apricots are subject to much the same diseases and insects as peach, with a similar treatment.

ASPARAGUS.

DISEASES.

RUST *(Puccinia asparagi)*. The first stage appears as yellow spots on the young stalks in early summer. The later stage shows as very small, brown blisters all over the plant, which cause it to die before it has stored enough food in the crown for next year's growth. Cut and burn the dead tops and cultivate afterward; cultivate early in the spring, keep all stalks cut off clean till the last of June and destroy all stray plants. Spray frequently after August first with soap Bordeaux mixture, or dust with flowers of sulphur every two weeks.

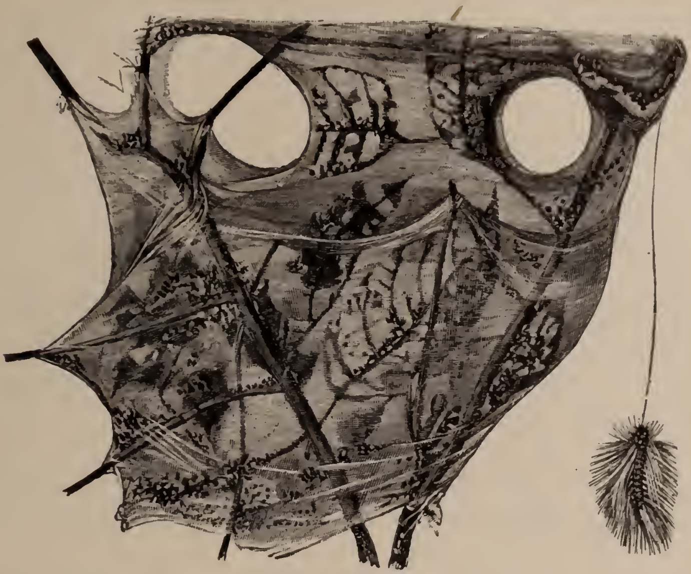

Fig. 25—The Fall Web-Worm; suspended larva and sections of web. (After Riley.)

LEOPARD SPOT AND ANTHRACNOSE cause much less injury.

INSECTS.

ASPARAGUS BEETLE *(Crioceris asparagi).* Small beetle; eats the plant. Spray with arsenical, adding resin soap after cutting season. Apply air-slaked lime when young first appear.

TWELVE-SPOTTED ASPARAGUS BEETLE *(Crioceris duodecimpunctata.)* Treatment same as for above species.

ASTER.

YELLOWS. China asters are affected with a disease similar to peach yellows. Destroy affected plants.

BARLEY.

RUST AND SMUT, etc. See wheat, which has about the same troubles.

BEAN.

DISEASES.

ANTHRACNOSE *(Colletotrichum lindemuthianum)* causes ulcer-like spots on leaves and pods. Plant perfect, unspotted seeds. Spray when plants are two to three inches high with Bordeaux mixture; repeat in two weeks and again after they bloom. The wax varieties are more susceptible to the disease.

BLIGHT *(Bacterium phaseoli)* causes watery spots in pods and dead patches on the leaves. Spraying frequently with Bordeaux mixture is a partial preventive. Do not plant beans on infected soil.

DOWNY MILDEW *(Phytophthora phaseoli).* A white mildew appears on the pods. It is very destructive to Lima beans. Spraying frequently with Bordeaux mixture, and, after the pods form, with ammoniacal copper carbonate will greatly reduce the disease. Plant healthy seed on well-drained soil.

RUST, LEAF-SPOT AND POWDERY MILDEW occur less frequently and are not very destructive.

INSECTS.

BEAN LEAF-BEETLE *(Cerotoma trifurcata).* (Figure 26.) Apply arsenical; repeat, if necessary.

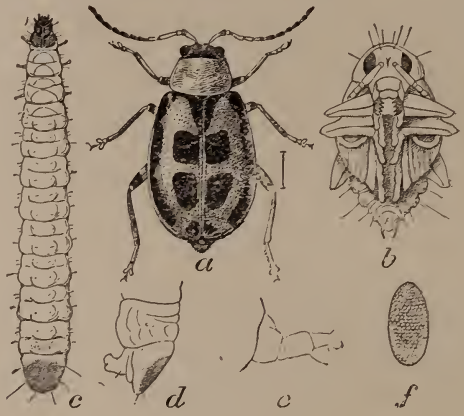

Fig. 26—The Bean Leaf-beetle; a, adult beetle; b, pupa; c, larvæ. (After Chittenden.)

COMMON BEAN WEEVIL *(Bruchus obtectus).* When beans are stored apply carbon bi-sulphide.

BEAN LADYBIRD *(Epilachna corrupta).* A spotted beetle; injures by eating foliage, apply arsenical.

TWELVE-SPOTTED CUCUMBER BEETLE *(Diabrotica duodecimpunctata).* Small, spotted beetle; injures by eating foliage. Apply arsenical.

BEET.

Leaf-spot *(Cercospora beticola)* may cause some loss to the beet foliage. Bordeaux mixture every two weeks will keep it off. Potato scab and several other less important root and leaf diseases occur on the beet.

BLACKBERRY.

Anthracnose, Crown-gall, Leaf-spot and Rust of the blackberry are the same as those of the raspberry, which see. The latter two are more frequently seen on blackberry than on raspberry.

Rose Scale *(Aulacaspis rosae)*. Whitish scale insect; injures by sucking. Destroy badly infested canes. Spray with 10 to 12 per cent. kerosene emulsion during May.

Raspberry Root-borer *(Bembecia marginata)*. Larva about an inch long; bores into roots. Destroy infested parts. See raspberry insects.

BLUE GRASS.

In wet seasons blue grass lawns may be seriously injured by *Rust* and *Mildew (Erysiphe graminis)*. Spraying with Bordeaux mixture would probably be beneficial, or dust with sulphur for the mildew.

BROOM CORN.

See sorghum which is similarly affected.

BUCKWHEAT.

Leaf-blight *(Ramularia rufo-maculans)* produces whitened spots on the leaves and kills them, but is not destructive enough to warrant treatment.

CABBAGE.

Diseases.

Black-rot *(Pseudomonas campestris)* causes dwarfed one-sided or partly rotted heads. It is first indicated by darkened veins or fibers. Soak seed fifteen minutes in 1 to 1000 solution corrosive sublimate or formalin, 1 part to 250 of water. Plant strong, healthy plants and keep them so by good cultivation. Avoid wet situations and infected land, especially for plant bed. Destroy diseased plants. No very satisfactory treatment is known.

Club-root *(Plasmodiophora brassicae)*. The roots are much swollen and distorted and the heads make poor growth. Fresh lime 75 bushels per acre, worked into freshly plowed ground in the fall is beneficial for infected land. The fungus lives in the soil for many years and may also live on mustard, turnips and many weeds like shepherds purse, peppergrass, etc. Avoid low wet ground. Destroy diseased plants.

WILT *(Fusarium sp.)*. The fungus lives in the soil and attacks the plants through the roots causing wilt and dropping of the leaves. Avoid infected land. No good treatment known.

SOFT-ROT *(Bacterial)* usually follows other diseases causing the heads to decay and become foul smelling. No treatment.

DOWNY MILDEW *(Peronospora parasitica)*. The young leaves in the plant bed show a downy appearance in spots which finally die. Older plants are sometimes similarly affected in the outer leaves. Reduce the amount of water given plants and spray with Bordeaux mixture.

Other not very serious diseases are *White-rust (Albugo candida), Powdery mildew (Oidium brassicae)* and *Leaf blight (Macrosporium brassicae)*. The later causes the black spots on the outer leaves of heading cabbage.

INSECTS.

CABBAGE MAGGOT *(Pegomya brassicae)*. Larvae injure roots. Place tarred paper card around young plant. Apply crude carbolic acid emulsion to plants after they are set. Repeat once a week until about May 15th.

IMPORTED CABBAGE-WORM *(Pontia rapae)*. Green larvæ; eat foliage of plants. Apply arsenical as dust or spray. Repeat as necessary.

CABBAGE LOOPER *(Autographa brassicae)* and CABBAGE MAMESTRA *(Mamestra trifolii)*. Larvae eat foliage. Spray with arsenical. Plant turnips, radishes, or other plants of mustard family for trap crops.

CUT WORMS. A number of species of cut worms injure this plant as well as other crucifers. Cultural methods together with poisoned baits just before the plants are put out will aid in suppressing the pests.

CABBAGE PLANT LOUSE *(Aphis brassicae)*. Sucking insect. Apply 15 per cent. kerosene emulsion.

HARLEQUIN CABBAGE-BUG *(Murgantia histrionica)*. A bright red, yellow and black mottled bug; injures by sucking. Plant trap crop of kale and mustard. Kill bugs on these plants by applying pure kerosene to plants or by cutting.

CALLA.

SOFT-ROT *(Bacillus aroideae)*. The leaves rot off near the ground. Select healthy corms for planting and change the soil of beds every three or four years.

CANTELOUPE.

DISEASES.

LEAF-BLIGHT *(Alternaria brassicae nigrescens)*. Somewhat circular brown spots appear on the leaves and finally kill them. The melons on affected vines are of poor quality. Spray with Bordeaux mixture at intervals of two weeks from the first bloom until fruit is nearly grown. Resistant strains are being developed.

Wilt or Bacteriosis *(Bacillus tracheiphilus)*. The whole vine or entire branches suddenly wilt, though others near by may remain healthy. Pull and burn withered vines. Keep off the squash bugs. (See under cucumber insects).

Downy Mildew and Anthracnose are the same as on cucumber which see. Some minor leaf and fruit diseases and another wilt also occur, but not frequently.

Insects.

Melon aphis *(Aphis gossipii)*. Green plant louse; does injury by sucking. Apply 15 per cent. kerosene emulsion.

Flea Beetle *(Epitrix cucumeris)* Small dark beetles, very active, spray with an arsenical with Bordeaux mixture, then apply wood ashes or air slaked lime.

CARNATION.

Diseases.

Rust *(Uromyces caryophyllinus)*. Small, dark purplish brown spots breaking through the leaf surface. Destroy diseased portions and use clean stock for propagation. Spray with Bordeaux mixture adding 2 pounds soap to the barrel. Some varieties are more subject to the rust than others.

Stigmonose. Many small brownish spots and yellowing of affected leaves due to aphid punctures and associated with bacteria appear on the foliage. (See methods of controlling aphis.)

Leaf mould *(Heterosporium echinulatum)* causes dark, unsightly often ring-like spots on the leaves, etc. Spray with Bordeaux mixture every two weeks, adding soap to make it stick.

Stem-rot *(Rhizoctonia)*. No good remedy.

Some other less prominent fungus diseases are *leaf spot, anthracnose* and *wilt*. Also a disease in which the buds mature but fail to open, has been seen in Maryland.

Insects.

Aphis *(Aphis sp.)*. Plant louse, injures by sucking. Apply fir-tree oil, 1 to 20, or common soap, 5 oz. to one gallon water.

CARROT.

Leaf-spot. See celery leaf-spot which is the same.

CAULIFLOWER.

The cauliflower insects and diseases are about the same as those of cabbage.

CELERY.

DISEASES..

LEAF-BLIGHT *(Cercospora apii).* The outer leaves show light brown spots, especially about the edges, and finally die. Spray from three to five times with Bordeaux mixture.

HEART-ROT *(Bacterium apii).* The heart is blackened and decayed.

PITHINESS is due to lack of care in selecting seed from good plants.

INSECTS.

CELERY LOOPER *(Plusia simplex).* Larvæ eat foliage. Apply arsenical.

CATERPILLAR *(Papilio polyxenes).* Larvæ foliage. Apply arsenical.

CHERRY.

DISEASES.

LEAF-SPOT *(Cylindrosporium padi).* Brown circular spots on the leaves. They may become so abundant that the leaf falls and often leaves the cherry tree without foliage early in summer. Weak Bordeaux mixture as soon as the leaves are out and again two weeks later.

POWDERY MILDEW *(Podosphaera oxyacanthae)* causes a whitish appearance on the young twigs and leaves. Treat as for leaf-spot.

BLACK-KNOT *(Plowrightia morbosa).* See under plum.

BROWN-ROT. See under peach.

TWIG-BLIGHT. See under peach.

ROOT-ROT. Great difficulty has been experienced in recent years in growing sweet cherry trees. A few years after planting, the root dies and of course soon after the whole tree follows. The cause is said to be lack of harmony between stock and scion and the trees grafted on Mazzard stock are said to do much better.

INSECTS.

CHERRY APHIS *(Myzus cerasi).* Green plant louse; injures by sucking; apply 15 per cent. kerosene emulsion.

PLUM CURCULIO *(Conotracheus nenuphar).* See apple.

PEAR SLUG *(Eriocampoides limacina).* Dark green slug; eats upper side of foliage, apply arsenical or dust with air-slaked lime.

CHERRY SCALE *(Aspidiotus forbesi).* Small, dark scale, similar to San Jose scale. Apply lime-sulphur wash in early spring, while trees are dormant.

CHESTNUT.

DISEASES.

LEAF-SPOT *(Septoria ochroleuca)*. Small brown spots on leaves. Spray with Bordeaux mixture. The Japan varieties are not much troubled.

POWDERY MILDEW *(Phyllactinia suffulta)* forms white patches on leaves in autumn, does little damage and could be controlled by applications of Bordeaux mixture or sulphur dust.

GREEN MOULD *(Penicillium)* often spoils the nuts, entering through the stigma or insect injuries. No remedy.

Wild chestnut trees often die through the injuries to the roots by stock and fires and by parasitism of wood-rotting fungi.

INSECTS.

LARGER CHESTNUT WEEVIL *(Balaninus proboscideus)*, LESSER CHESTNUT WEEVIL *(Balaninus rectus)*. Clay-colored snout beetles. Larvae injure nuts. Gather nuts as soon as they fall. Sell, or put in tight boxes as soon as possible to catch the larvae when they come out of the nuts.

CHRYSANTHEMUM.

DISEASES.

LEAF-SPOT *(Septoria chrysanthemi)*. Dark colored spots on the leaf. Spray with Bordeaux mixture or if it is undesirable to discolor the leaves with this spray, use ammoniacal copper carbonate or other clear fungicide.

RUST *(Puccinia chrysanthemi)*. Dark brown, raised spots as large as a pin head scattered over the leaves. Pick off and burn rusted portions and use healthy shoots for propagation. Often quite serious.

INSECTS.

APHIS *(Aphis sp.)*. Plant louse, injures by sucking. Apply firtree oil 1 to 20, or common soap solution.

TWO-SPOTTED RED-SPIDER *(Tetranychus bimaculatus)*. See geranium.

CLOVER.

DISEASES.

ANTHRACNOSE *(Colletotrichum sp.)*. Affects young plants in summer, killing the stem and leaves. New and not yet thoroughly studied.

DODDER *(Cuscuta epithymum)*. See alfalfa dodder.

BROOM RAPE *(Orobanche minor)*. A yellowish leafless weed as tall as the clover and attached to its root. Destroy whenever found. It is not yet common in Maryland.

RUST *(Uromyces trifolii)*. Small rusty elevated spots on leaves in summer and autumn. Usually not so injurious as to make treatment profitable.

BLACK-SPOT *(Phyllachora trifolii)*. Small black spots on leaves. Not very injurious. Another leaf-spot also occurs.

INSECTS.

CLOVER ROOT-BORER *(Hylastinus trifolii)*. Larva injures roots of plants. Plow infested fields when hay crop is cut.

CLOVER STEM BORER *(Languria mozardi)*. Beetle appears in June; larva works in stem. Keeping fields cut in summer and fall will control it.

CLOVER HAY WORM *(Hypsopygia costalis)*. Larvae injure hay in mow. Do not stack hay two successive seasons in the same place. Clean barn out before putting in new hay.

CORN.

DISEASES.

LEAF-BLIGHT *(Helminthosporium inconspicuum)*. Long, light brown or withered stripes appear on the leaves; often the lower leaves are entirely killed and dry up green. No remedy.

SMUT *(Ustilago zeae)*. Large swellings appear on the ear and other parts, white at first and later filled with black dust. Cut off and burn the smutted portions before dry. Often worse on early sweet corn varieties, but does not do enough damage on field corn to pay for treatment; not poisonous to stock.

RUST *(Puccinia sorghi)*. Small, oblong, rusty specks on leaves. Does little damage in this State.

WILT *(Pseudomonas Stewarti)* causes wilt of early sweet corn. Grow resistant varieties.

INSECTS.

CORN ROOT-WORM *(Diabrotica duodecimpunctata)*. 12-spotted beetle; larvæ eat small roots and burrow into larger roots and stalk of young corn. Rotation of crops.

CORN ROOT-LOUSE *(Aphis maidi-radicis)*. Lice suck the roots of plant. Rotation of crops and cultural methods.

CORN-STALK BORER *(Diatraea saccharalis)*. Brown-spotted caterpillars bore into the young stalks. Destroy old stalks of infested field. Rotation of crops.

CORN EAR-WORM *(Heliothis obscura)*. Larva injures ear of corn. Fall plowing. Rotation of crops.

ANGOUMOIS GRAIN-MOTH *(Sitotroga cerealella)*. Larva feeds in kernel of corn that is stored or after harvest. Fumigate with carbon bi-sulphide.

COWPEA.

WILT *(Neocosmospora vasinfecta tracheiphila).* The vines wilt and are stunted in growth. If the disease occurs in Maryland the Iron cowpea, which is resistant to it, can be grown. The *Root-knot* disease of the South can be overcome in the same way.

A *Leaf-spot* disease also occurs, but is not serious.

The cowpea in this state is so far remarkably free from serious diseases. For insects see bean.

CRANBERRY.

The cranberry is not grown in Maryland but is native in our mountain bogs. Its diseases and insects are well treated in Farmers' Bulletins Nos. 221 and 178 respectively, U. S. Department of Agriculture.

CUCUMBER.

DISEASES.

DOWNY MILDEW *(Plasmopara cubensis).* Yellowish angular spots on the leaves, which soon die as if frosted. Spray with Bordeaux mixture every ten days after July first. When spraying is to be practiced the vines should be planted so that a sprayer can be hauled through them.

ANTHRACNOSE *(Colletotrichum lagenarium)* causes circular dead spots on the leaves and more elongated ones on the stem. Spray with Bordeaux mixture as soon as the disease appears. Also occurs on melons.

WILT, described under cantaloupe also occurs on cucumber.

INSECTS.

PICKLE WORM *(Diaphania nitidalis).* Larva bores into cucumber.

STRIPED CUCUMBER BEETLE *(Diabrotica vittata).* Beetle eats foliage. (Figure 27.) Apply arsenical, wood ashes, air-slaked lime, etc.

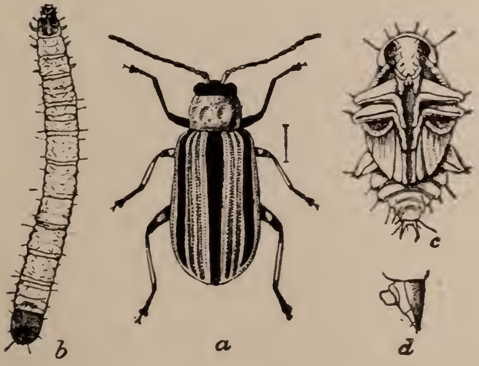

Fig. 27—The Striped Cucumber Beetle. (After Riley.)

TWELVE-SPOTTED CUCUMBER BEETLE *(Diabrotica duodecimpunctata)*. Beetle eats foliage. See above.

SQUASH LADYBIRD *(Epilachna borealis)*. Larva injures foliage. Apply arsenical.

COMMON SQUASH-BUG *(Anasa tristis)*. Adult insect punctures vines. Clean culture. Destroy vines after securing crop. Catch bugs and destroy eggs.

CURRANT

DISEASES.

LEAF-SPOTS *(Septoria ribis* and *Cercospora angulata)*. Spotted leaves which fall prematurely. Spray with Bordeaux mixture as the leaves are unfolding and twice more at two-week intervals.

ANTHRACNOSE *(Gloeosporium ribis)*. Spots the leaves and stems. Treat as for leaf-spot.

MILDEW. See under gooseberry.

INSECTS.

IMPORTED CURRANT-BORER *(Sesia tipuliformis)*. Larva eats into center of stem where it bores up and down. Destroy all injured canes or stems.

SAN JOSE SCALE *(Aspidiotus perniciosus)*. See apple.

GOOSEBERRY SPAN-WORM *(Cymatophora ribearia)*. Larva eats foliage. Apply arsenical or helebore.

IMPORTED CURRANT WORM *(Pteronus ribesii)*. Larva eats foliage. Apply arsenical.

DEWBERRY.

See blackberry for its insects and diseases.

EGG PLANT.

ANTHRACNOSE *(Gloeosporium melongenae)*. Slightly sunken areas in fruit.

A leaf-spot occurs on the leaves; some diseases of potato also attack the egg plant.

EGGPLANT FLEA-BEETLE *(Epitrix fuscula)*. Beetles eat foliage. Apply arsenical with Bordeaux mixture or wood ashes and air slaked lime.

GERANIUM.

A rot causes the young plants to die in the cutting bed and a leaf-spot mars the foliage Both are caused by bacteria. Use clean soil and disinfect benches. Frequent spraying with Bordeaux mixture will keep them down.

MEALY BUG *(Pseudococcus citri)*. Injures by sucking. Contact insecticide. Kerosene or soap emulsion.

RED SPIDER *(Tetranychus bimaculatus)*. Spray with soap and water or water alone, hitting both sides of leaves. The mite seems to thrive in dry atmosphere.

GINSENG.

This plant is now being cultivated to a limited extent. Its diseases are described in Bulletin No. 219, Cornell Experiment Station.

GOOSEBERRY.

POWDERY MILDEW *(Sphaerotheca mors-uvae)*. Grayish mildewed areas on leaves and fruit. The leaves fall early and the fruit is seriously injured. Spray every two weeks after the buds swell with potassium sulphid, 1 oz. to 2 gallons of water.

LEAF-SPOT. See under currant.

GOOSEBERRY FRUIT-WORM *(Zophodia grossulariae)*. Larva burrows into berry. Hand picking. Dust bushes with air-slaked lime early in spring, repeating if washed off. This will deter moths from laying eggs. For other insects see currant.

GOURD.

Diseases about the same as for melons, cucumber, etc.

GRAPE.

DISEASES.

BLACK-ROT *(Guignardia bidwellii)*. The grapes rot, turn black and shrivel up. The disease may also spot the leaves and stems. Clean up and burn diseased leaves, fruit, etc. Spray vines, posts, etc., thoroughly, with Bordeaux mixture when buds are swelling. Spray again in two weeks when grapes are in bud. Keep the bunches of grapes covered with Bordeaux mixture until almost ripe. This will take from six to eight sprayings. Ammoniacal copper carbonate can be used for the last two times to avoid staining the fruit.

ANTHRACNOSE *(Sphaceloma ampelinum)*. Circular, slightly sunken spots with a lighter colored center appear on the fruit. It also spots the leaves and vines. Treat as for black-rot. The earlier sprayings are more important with this disease.

DOWNY MILDEW *(Plasmopara viticola)*. Yellow areas appear on the upper side of the leaves and underneath them a downy patch. It also attacks the fruit, causing a brown rot. Spray as for black-rot, except that the earlier sprayings are not necessary.

POWDERY MILDEW, WHITE-ROT, BITTER-ROT, etc., occur but are not so important and are controlled by the treatment which it is usually necessary to give for some of the above described diseases.

INSECTS.

BROAD-NECKED PRIONUS *(Prionus laticollis).* Injures roots by boring. Dig out and destroy.

GRAPE-VINE ROOT-WORM *(Fidia viticida).* Beetles feed on foliage, young larvæ feed on roots. Spray foliage with an arsenical. Thorough cultivation of ground.

GRAPE SCALE *(Aspidiotus uvae).* Injures vines by sucking. Apply strong solution of whale oil soap or lime-sulphur wash.

GRAPE-VINE FLEA-BEETLE *(Haltica chalybea).* Adult beetles and larvæ feed on the leaves. Apply arsenical with Bordeaux mixture. The latter is distasteful to the insect.

ROSE CHAFER *(Macrodactylus subspinosus).* Adult beetles eat flower and young grapes. Handpicking. Continuous applications of arsenate of lead may assist in controlling them.

There are a number of caterpillars of some of our largest moths that feed on the foliage of grapes to some extent. All can be controlled by an arsenical.

HORSECHESTNUT.

LEAF-SPOT *(Phyllosticta sphaeropsoidea).* This shade tree is often disfigured by the brown spots and dead leaves caused by this fungus. Spray with Bordeaux mixture when the leaves are half grown and at three week intervals afterward.

HORSE RADISH.

WHITE-RUST *(Albugo candida)* is common on leaves but does little harm. It occurs on many other plants of the mustard family.

IRISH POTATO.

See potato.

LETTUCE.

ROT OR DROP *(Sclerotinia libertiana).* The plants wilt and rot off near the ground. Careful regulation of water and temperature in lettuce houses will do much to keep down the disease. Give good ventilation and drainage. It is not very troublesome outdoors. Diseased plants should be burned and some have had good results with sterilized soil. A top coating of sterilized soil or sand one inch thick is recommended.

DOWNY MILDEW *(Bremia lactucae)* may attack young lettuce leaves. Avoid high temperature and too much water.

TOP BURN. The browning of the leaf tips is due to strong light after cloudy weather and too high temperature.

LILAC.

Powdery Mildew *(Microsphaera alni)* gives the leaves of lilac a grayish coating in autumn. It rarely does harm. Sulphur dust should control it.

Oyster-shell scale *(Lepidosaphes ulmi)*. Common on this plant, see bulletin 111, of this Station. Apply 15 per cent. kerosene emulsion middle of May.

San Jose scale *(Aspidiotus perniciosus)*. See apple.

MAPLE.

Blach-spot *(Rhytisma acerinum)*. Large, thick, black spots on the leaves. Not serious. Burning dead leaves and Bordeaux spraying in summer would be helpful.

Oyster-shell scale *(Lepidosaphes ulmi)*. See lilac.

MUSKMELON.

See canteloupe.

MUSTARD.

Mustard is subject to the club-root, black-rot, white-rust, and other diseases of cabbage.

OATS.

Rust *(Puccinia coronata)*. Rusty colored, dusty stripes covering the leaves. Very serious in lower portions of the state. No remedy.

Smut *(Ustilago avenae)*. The grain is replaced by a black dust. Before sowing sprinkle formalin solution (1 pint to 50 gallons water) at the rate of one gallon to the bushel over the pile of seed, while it is being shoveled over. After two or three hours spread out to dry.

ONION.

Onions in other states have been attacked by *rot, mildew, smut, blight,* etc., but none of these have proved serious in this state. The smut is the worst trouble and is controlled by dusting sulphur in the rows when seeding, or treating with formalin before sowing.

PARSNIP.

Parsnips are subject to about the same diseases as celery, especially the leaf blight.

Parsnip webworm *(Depressaria heracliana)*. Injures by eating. Apply arsenical.

Parsnip Leaf-miner *(Acidia fratria)*. Larva mines the leaves. Apply arsenical early.

PEA.

DISEASES.

BLIGHT *(Ascochyta pisi)*. Stems are killed near the ground; the leaves may be spotted and the whole plant wilt and die. Plant seed free from the disease and in soil where peas, beans, etc., have not been recently.

POWDERY MILDEW *(Erysiphe communis)*. A whitish coating shows on the leaves. Spray with Bordeaux mixture when it appears and later if needed. *Leaf spot* and other leaf diseases may also attack the pea but are not very troublesome.

INSECTS.

PEA LOUSE *(Nectarophora pisi)*. Plant louse; injures by sucking. Apply 15 per cent. kerosene emulsion. Plant crop early to avoid pest as much as possible.

COMMON BEAN WEEVIL *(Bruchus obtectus)*. See bean insects.

PEA WEEVIL *(Bruchus pisorum)*. Fumigate with carbon bi-sulphide.

PEACH.

DISEASES.

YELLOWS. (Figure 28.) The fruit ripens several days or weeks be-

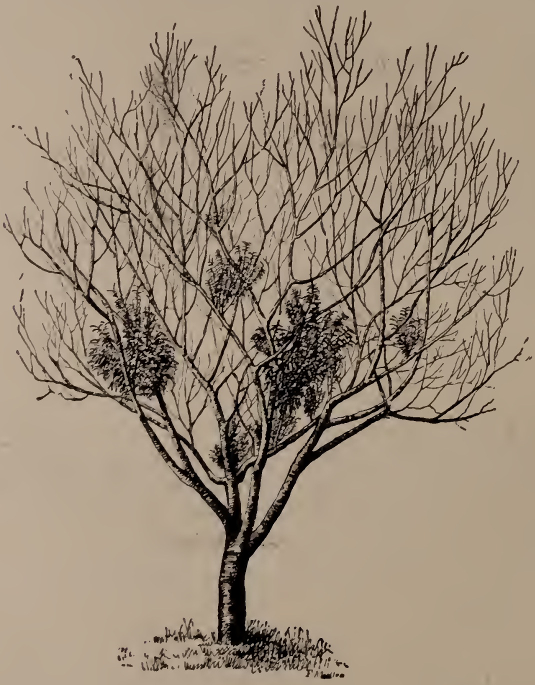

Fig. 28—Peach tree in last stages of the yellows.

fore healthy fruit of the same variety. The prematurely ripened fruit is red spotted and has red streaks through the flesh and the fruit is worthless. Later the leaf buds develop into slender twigs which have small, narrow, pointed, yellowish leaves and the tree soon dies. The disease may show on part of the tree only, though the whole tree be diseased. Examine all the trees carefully during the ripening period and afterward and pull up and burn every affected tree as soon as discovered no matter how slightly diseased. This will keep the disease down so that only a few cases appear each year, when if they are allowed to stand the disease spreads rapidly to the surrounding trees. The Maryland law requires the destruction of trees affected with the yellows.

Brown-rot *(Sclerotinia fructigena)*. The fruit rots with a soft, brown rot and is covered with grayish dusty spots of the fungus spores. The rotting fruit shrivels up and may hang on the trees over winter in the mummified condition. The fungus also attacks the twigs and kills them. It sometimes starts early causing *blossom-blight*. Gather and burn the rotten fruit remaining on trees or ground in fall. Prune so as to admit air and light. Select orchard sites with good soil and air drainage. Spray just before the buds open with 5-5-50 Bordeaux mixture. Spray when fruit is one-fourth inch in diameter with 3-9-50 Bordeaux mixture. Give two or three more sprayings at two week intervals if there is much danger of loss from rot. There is considerable danger of even the weak Bordeaux mixture injuring the leaves.

Leaf-curl *(Exoascus deformans)*. As the first leaves mature, part of them become thickened, whitish and wrinkled and drop off. If many are affected the young fruit may also drop. Some varieties, as Elberta, are more subject to the disease. Spray before the buds open, with Bordeaux mixture or lime-sulphur wash. The former is better.

Scab *(Cladosporium carpophilum)*. Also called *black-spot* and *mildew*. Black spots appear on one side of the fruit. If abundant, the fruit may shrivel or crack. Spray with 3-9-50 Bordeaux mixture the second week in June and again two or three weeks later.

Crown-gall. Rough projecting galls an inch or more in diameter on the root usually near the surface of the ground. (Figure 29). The affected trees make poor growth and often die. Destroy affected trees. In the nursery avoid infected soil as the disease is contagious.

Gumflow. Many different diseases and injuries cause a production of gum from the peach bark. A bacterial disease has this symptom and kills the bark in large patches. Badly affected trees or branches should be destroyed.

Winter injury. The peach is especially subject to injury by low temperature. Trees well cared for and in vigorous condition but well hardened and not full of sap are less injured. Badly injured trees should be cut back.

Leaf-spot or Shot-hole *(Cercospora persica)* and other fungi or spray injury). Spots about one-eighth inch in diameter, which may drop out, leaving small holes in the leaves. Usually not serious. If numerous the whole leaf may fall.

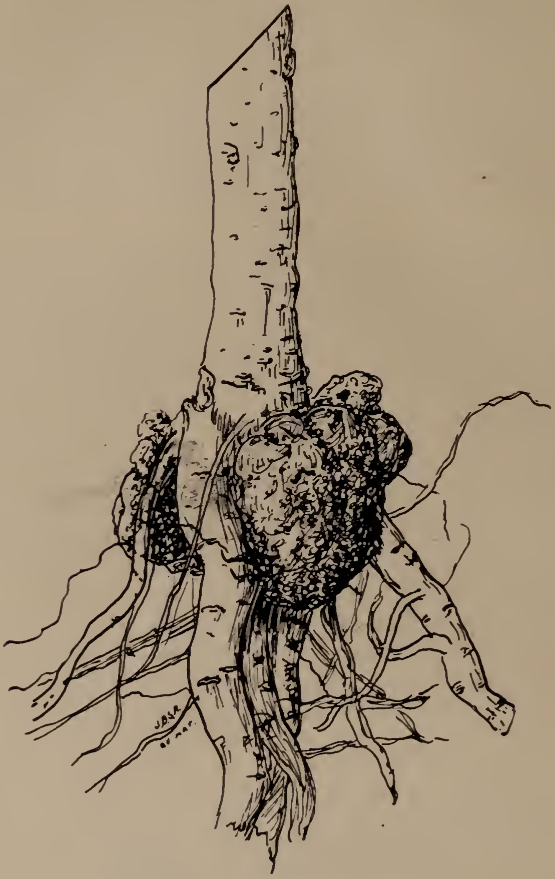

Fig. 29—Crown-gall on peach root.

Frosty Mildew *(Cercosporella persica).* Whitish patches on leaves and young twigs; usually not serious except on a few varieties, as Tilletson.

Insects.

Black peach aphis *(Aphis persicae-niger).* Dark colored plant louse; attacks roots and twigs. Treat as woolly aphis, for which see apple.

Peach-tree borer *(Sanninoidea exitiosa).* Larvae bore into trunks of trees. Remove borers in October and April.

San Jose scale *(Aspidiotus perniciosus).* See apple.

PEACH SCALE or LECANIUM *(Eulecanium nigro-fasciatum)*. Soft, rounded scale; injures by sucking. Apply 15 per cent. kerosene emulsion, about middle of May.

FRUIT-TREE BARK-BEETLE. See apple.

PLUM CURCULIO. See apple.

PEAR.

DISEASES.

BLIGHT, also called *Fire-blight* and *Twig-blight (Bacillus amytovorus)*. The twigs die from the tips backward, usually starting from flowers. The leaves on affected parts die, turn black and hang on. In many cases the disease works back into large branches or the body of the tree killing the bark and thus causing body blight or cankers. Cut out blighted portions several inches below the visible affectation, disinfecting the cut surface and frequently the knives or other tools used, in corrosive sublimate solution (1 to 1000) which can be carried on a sponge or cloth. Cut out blight especially in fall and spring before blooming time. Allow no small twigs or spurs on large branches or body of tree. Prune to vase form and frequent branching of main limbs. Occurs also on apple and quince.

CANKER AND BODY-BLIGHT. Same as for apple, but spreading more rapidly.

LEAF-BLIGHT *(Entomosporium maculatum)*. The leaves become spotted and fall early. The fruit also may be affected. Spray with Bordeaux mixture after the blossoms fall. Spray a second and third time at two weeks intervals. This treatment prevents the very serious loss from early leaf fall and second growth as well as spotted or cracked fruit. In the nursery spray 5 or 6 times at 2 week intervals as long as young leaves are forming.

SCAB *(Venturia pirnia)*. Appearance and treatment about as in apple scab.

LEAF-SPOT *(Septoria pirina), Crown-gall, Rust, etc.,* also occur.

INSECTS.

TWIG GIRDLER *(Oncideres cingulatus)*. Adult eats twigs so winds break them off; larvae undergo transformations in fallen twigs. Burn fallen twigs.

SAN JOSE SCALE *(Aspidiotus perniciosus)*. See apple.

PEAR PSYLLA *(Psylla pyri)*. Injures by sucking. Apply kerosene emulsion.

PEAR SLUG *(Eriocampoides limacina)*. Injures by eating foliage. Apply arsenical or air slaked lime.

PEAR-LEAF BLISTER *(Eriophyes pyri)*. Mite injures leaves. Apply 10 per cent. kerosene emulsion while trees are dormant.

SCURFY SCALE *(Chionaspis furfura)*. See apple.

PEPPER.

ANTHRACNOSE *(Colletotrichum nigrum* and *Gloeosporium piperatum),* causes decayed, slightly sunken spots in the red pepper fruits. Spray with Bordeaux mixture.

PLUM.

DISEASES.

BLACK-KNOT *(Plowrightia morbosa).* Large black swellings on twigs. (Figure 30). Especially destructive to damsons, also occurs on cherry, especially the wild black cherry. Cut out and burn the knots in autumn, cutting four or five inches below the knot Cut out

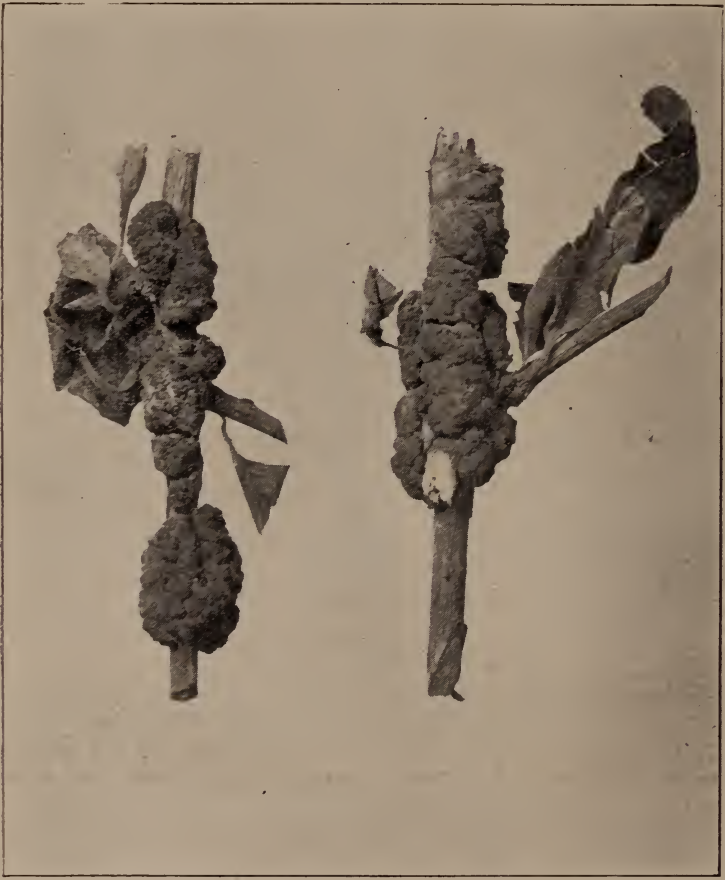

Fig. 30—Black-knot on plum.

new knots as they appear in summer on young branches. If very bad spray with Bordeaux mixture when buds begin to swell and repeat with peach Bordeaux mixture in two weeks.

Canker. Sunken spots or knots extending through the wood on one side of branches. The branches may break off at the injured portion. Examine nursery stock and discard affected trees. Cut off and burn cankered branches in the orchard.

Leaf-blight or Shot-hole *(Cylindrosporium padi)*. Treat as in cherry but use peach Bordeaux mixture.

Plum-pockets *(Exoascus pruni)* causes bladdery distorted fruit. One may spray as for peach leaf curl but fungus may live over in the twigs.

Insects.

Peach-tree borer *(Sanninoidea exitiosa)*. See peach.

San Jose scale *(Aspidiotus perniciosus)*. See apple.

Hop-vine louse *(Phorodon humuli)*. Plant louse, injures by sucking. Apply kerosene emulsion 15 per cent.

Plum curculio *(Conotrachelus nenuphar)* (Figure 31). See apple.

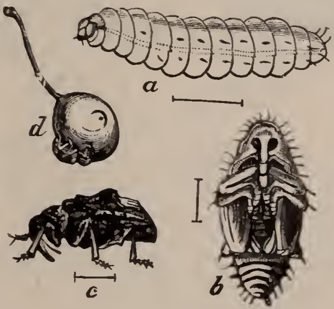

Fig. 31—The Plum Curculio; a, larva, b, pupa; c, adult; d, crescent-shaped slit on fruit. (After Riley.)

POPLAR, CAROLINA.

Anthracnose *(Marsonia populi)*. One of the characteristics of this tree, often planted along streets for shade and ornament, is the early fall of the leaves due to this fungus. Spraying the portions of the tree in reach with Bordeaux mixture in June and July is recommended.

POTATOES, IRISH.

Diseases.

Early-blight *(Alternaria solani)*. Brown spots with faint rings in them on the leaves. (Figure 32). These gradually cover the leaf killing it. Spray with Bordeaux mixture, spraying three times between June 15, and digging time in the fall. The McCormick potato is not much troubled with this disease.

LATE-BLIGHT *(Phytophthora infestans)*. In moist summer weather, appears suddenly as soft, bad smelling, dark areas in the leaves and may kill whole fields in a short time. It is not common in this state. Treatment for this disease same as for early blight. The affected tubers may rot.

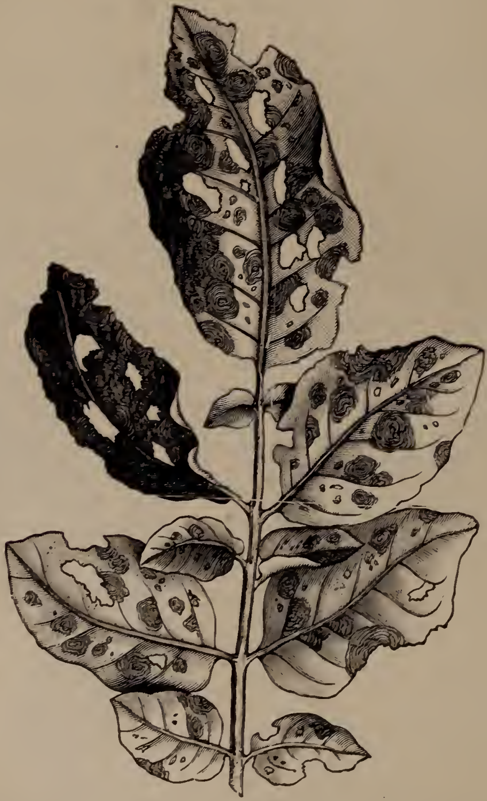

Fig. 32—Early blight of potato. (From Galloway, Farmers' Bulletin 91, U. S. Dept. Agriculture.)

BROWN-ROT *(Bacillus solanacearum)*. The leaves and stem wilt and shrivel and the tubers later show a wet rot. Thorough spraying with Bordeaux mixture and arsenicals to keep down insects which carry the germs. Do not plant on land which has recently borne potatoes, tomatoes or egg plant, all of which are subject to the disease. Store potatoes in cool, dark places.

DRY-ROT *(Fusarium oxysporum)*. Lighter colored and more or less rolled up leaves. The tubers later may be destroyed at least at one end by dry rot. Avoid infected soil and do not plant tubers that have internal brown or black streaks.

Scab *(Oospora scabies).* Scabby spots on the tubers. (Figure 33.) Soak uncut seed tubers in formalin, one-half pint to fifteen gallons water, for two hours and plant on scab free land. Avoid use of alkaline fertilizers. Scab resistant varieties are on the market.

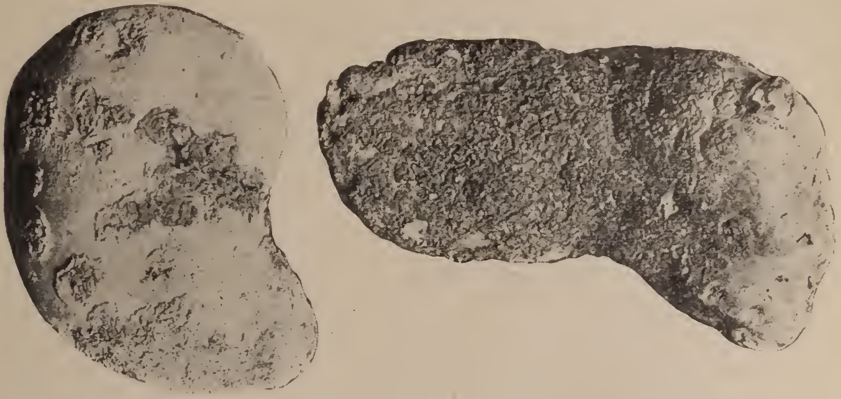

Fig. 33—Potato Scab.

For further information on potato diseases see Bulletin 108, of the Maryland Agricultural Experiment Station, in which several less important diseases are treated.

Insects.

Potato stalk-weevil *(Trichobaris trinotata).* Larva bores into stalk or branches. (Figure 34). Burn old vines. Clean culture.

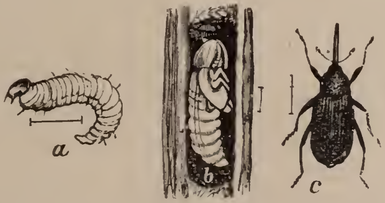

Fig. 34—The Potato Stalk Weevil; a, larva; b, pupa; c, adult beetle. (After Riley.)

Colorado potato beetle *(Leptinotarsa decemlineata).* Beetles eat foliage. Apply arsenical.

Blister beetle *(Epicauta vittata, Macrobasis unicolor).* Beetle eats foliage. Apply arsenical. Drive from patches with a brush into a heap of straw and then burn.

QUINCE.

The quince is subject to much the same diseases and insects as pear and apple, which see for treatment. It is especially liable to injury by the *Black-rot, Blight, Rust* and *Leaf-spot,* which, together, almost destroy the quince crop annually. They could be easily prevented by a little trouble in spraying and cutting out blight and black rot injuries.

RADISH.

The radish is subject to most of the diseases found in cabbage, but is rarely seriously injured by them.

RASPBERRY.

ANTHRACNOSE *(Gloeosporium venetum)*. White scabby spots on the young canes and on leaves so that they are unable to ripen fruit properly. Spray with Bordeaux mixture before leaves open and twice afterward with a weaker mixture. Cut out badly diseased canes. Also occurs on blackberry.

RUST *(Gymnoconia interstitialis)*. The leaves become bright orange color from the coating of spores of the fungus and the whole plant is seriously injured. Dig up and burn the diseased plants as soon as the yellow color begins to appear. Also occurs on blackberry.

CROWN-GALL. Large knots on the roots, causing poor growth and death of the canes. Dig and burn and replant on new ground with healthy stock. The disease also occurs on peach and some plums.

LEAF-SPOT. See blackberry.

For insects see blackberry and dewberry.

ROSE.

DISEASES.

POWDERY MILDEW *(Sphaerotheca pannosa)*. The leaves are somewhat wrinkled or curled and covered with a whitish powder. Troublesome in greenhouses when there is uneven temperature. It is bad on some varieties especially the Ramblers outdoors. Dust with sulphur outdoors or spray with Bordeaux mixture. Inside observe proper regulation of heat and spread sulphur paste on heating pipes.

LEAF-BLOTCH *(Actinonema rosea)*. Radiating black patches appear on the leaves and soon cause them to drop. Spray with Bordeaux mixture or one of the clear fungicides in midsummer.

RUST, LEAF-SPOT AND ANTHRACNOSE are less troublesome.

INSECTS.

ROSE SCALE *(Aulacaspis rosae)*. Injuries by sucking. Apply strong soap solution. Cut out badly infested branches.

PLANT LICE *(Aphis sp.)*: Injure by sucking; apply 10 per cent. kerosene emulsion.

ROSE CHAFER *(Macrodactylus subspinosus)*. See grape.

RYE.

RUST and SMUT are about the same as on wheat.

SORGHUM.

Smut of the grain and Bacterial Blight, causing reddish, diseased patches on leaves and stalks, have not yet been found serious in Maryland.

SQUASH.

Squash-vine borer *(Melittia satyriniformis).* Larvae bore into squash-vine. Cut pest out of wilting vines. Grow a summer variety as a trap crop to protect the late varieties.

Striped cucumber-beetle *(Diabrotica vittata).* See cucumber.

Squash ladybird *(Epilachna borealis).* See cucumber.

Common squash-bug *(Anasa tristis).* See cucumber.

The squash is subject to much the same diseases as melons and cucumbers.

STRAWBERRY.

Diseases.

Leaf-spot *(Sphaerella fragariae),* erroneously called *rust.* Small brown spots surrounded with a reddish ring on the leaves. Some other fungi also cause spots on strawberry. All are controlled by burning over the patch in autumn or winter. Spraying with Bordeaux mixture before blossoming and after fruit is picked is helpful. Some varieties, as Gandy, are more injured by the disease.

Powdery mildew *(Sphaerotheca castagnei).* Somewhat wrinkled and white mildewed leaves, usually not abundant. Spray with Bordeaux mixture or dust with sulphur.

Insects.

Strawberry root-louse *(Aphis forbesi).* Burn off patches in late winter, thus destroying the eggs. Cultural methods.

White grub *(Lachnosterna arcuata)* Larvae eat roots of plant, Rotation of crops. Apply salty fertilizers.

Strawberry weevil *(Anthonomus signatus).* Beetles cut off buds in which eggs are laid. Grow resistant varieties. Clean culture.

Strawberry leaf-roller. *(Ancylis comptana).* Injures foliage. Destroy old beds in fall. Spray early in spring with arsenical.

SWEET POTATO.

Diseases.

Black-rot *(Ceratocystis fimbriata).* A black decay of the potato and black spots or streaks on the young slips or vines. (Figures 35, 36). Keep the beds from contact with affected potatoes and use for slips only those perfectly free from the disease. Do not plant any slips that show any sign of the *"black shank."*

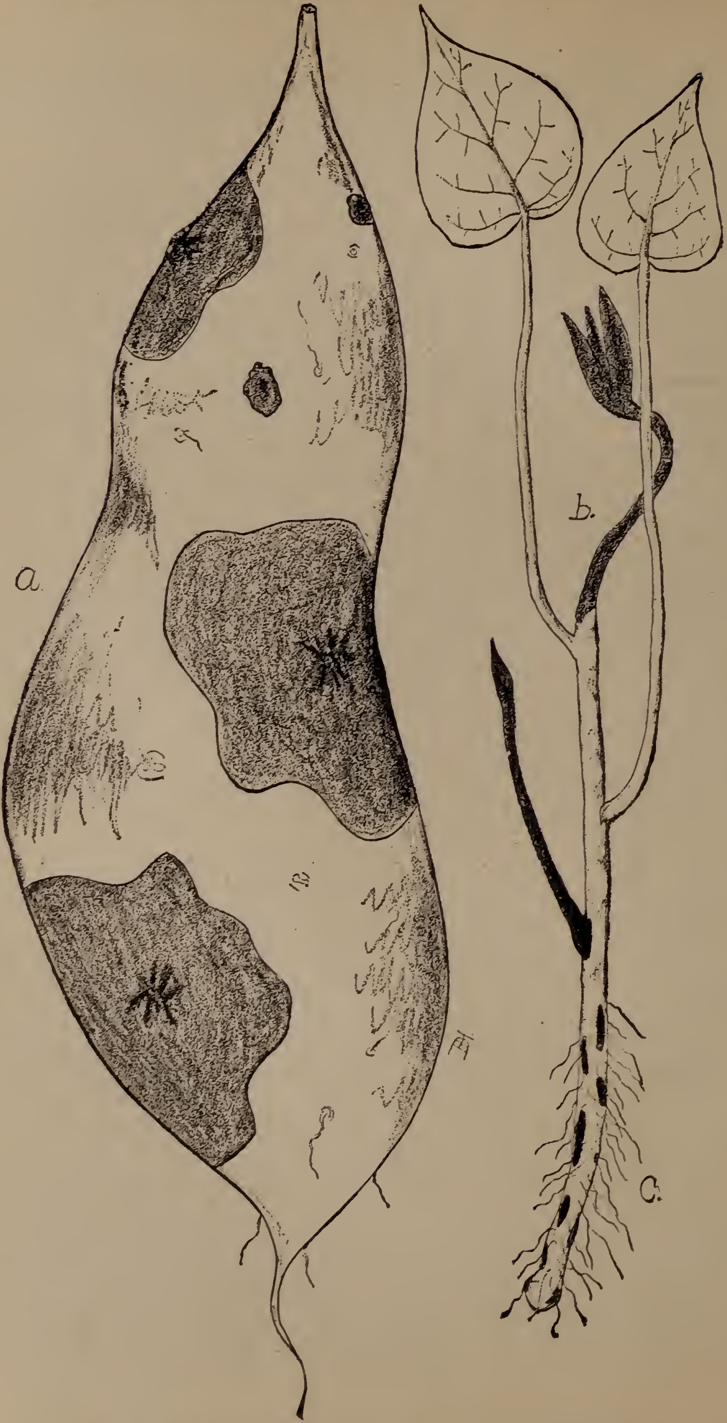

Fig. 35—Sweet potato black-rot on root and young stem.

ROT of several kinds occurs in storage and is prevented by careful attention to storage conditions, proper temperature, dryness, discarding decayed potatoes, etc.

INSECTS.

CUT WORMS (various species). Injure by cutting and eating stem. Fall plowing, poison baits on land just before crop is planted.

SWEET-POTATO FLEA-BEETLE *(Chaetocnema confinis)* Adult beetles eat channels in leaves. Apply arsenical with Bordeaux mixture. The latter is distasteful to the insect.

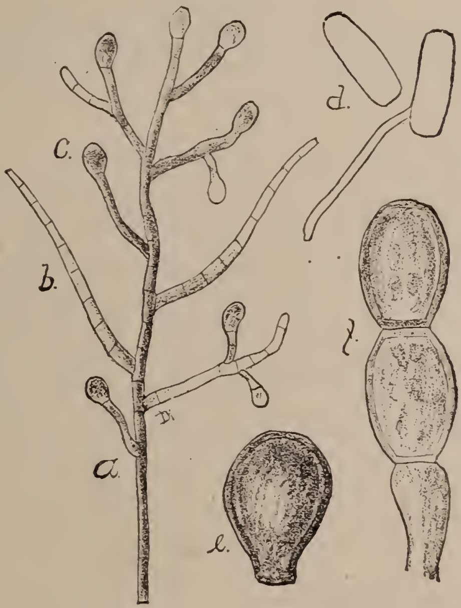

Fig. 36—Fungus causing black-rot of sweet potato; highly magnified.

GOLDEN TORTOISE BEETLE *(Coptocycla bicolor)*. Injures foliage by eating. Apply arsenical with Bordeaux mixture.

TWO-STRIPED TORTOISE BEETLE *(Cassida bivittata)*. Same as preceding species.

CUCUMBER FLEA-BEETLE *(Epitrix cucumeris)*. See cucumber.

SYCAMORE.

ANTHRACNOSE *(Gloeosporium nervisequum)* or blight. The leaves and young twigs are killed in early summer. Bordeaux mixture just before the leaves appear would be effective when practicable.

TOBACCO.

DISEASES.

MOSAIC DISEASE, FRENCHING. The leaves have a mottled appearance and are more or less wrinkled or curled. The disease is easily transmitted from one plant to another and can be communicated by handling in any way the growing plants. Diseased plants should be destroyed especially in the bed.

ROOT ROT, DAMPING-OFF and other diseases that sometimes injure the young plants in the bed can be largely controlled by using entirely new beds each year, or sterilizing them by burning or otherwise.

Such troubles of the curing house as *pole burn, stem rot,* etc., might be helped considerably by disinfecting the houses before putting in the tobacco by spraying the inside of the house, poles, etc., with formalin solution as used for potato scab; and removing and burning diseased stems.

INSECTS.

TOBACCO FLEA-BEETLE *(Epitrix parvula).* Larvae injure roots, beetles feed on leaves. Apply arsenical.

CUCUMBER FLEA-BEETLE *(Epitrix cucumeris).* See cucumber.

NORTHERN TOBACCO WORM *(Phlegethontius quinquemaculata).* SOUTHERN TOBACCO WORM, HORNBLOWER *(Phlegethontius sexta).* Larvae eat foliage of plant. Apply arsenical. Hand picking. Turkeys in the tobacco fields will aid in controlling the pest.

CIGARETTE BEETLE *(Lasioderma testaceum).* Insect eats small holes in the finished products, cigarettes or cigars; also in cured leaves, etc. Fumigate with carbon bi-sulphide or hydrocyanic acid gas.

TOMATO.

DISEASES.

LEAF-SPOT OR LEAF-BLIGHT *(Septoria lycopersici).* Small spots on the lower leaves which die finally, leaving only the upper young leaves to bear all the burden of maturing fruit. Very destructive. Spray the plants with Bordeaux mixture and dip the leaves in it before planting. Give about three sprayings in the field, the first, two or three weeks after the plants are set, and the last just before the fruit is grown. Early sprayings in the bed are very helpful.

SOUTHERN BLIGHT *(Bacillus solanacearum).* The plants wilt and show black streaks in the stem. This is the same as the brown-rot of the potato and has similar treatment.

LEAF-MOLD OR SCAB *(Cladosporium fulvum).* Greenish brown patches on the underside of the leaves. It is especially troublesome on tomatoes grown in the greenhouse. Spray thoroughly and frequently with Bordeaux mixture.

ROT. There are several rots of tomatoes, due to different causes. The point-rot, troublesome in the greenhouse, is due to lack of sufficient water. The bacterial rot in the field can be controlled to some extent by removing the rotten tomatoes as they appear, and by spraying with Bordeaux mixture and arsenicals to keep down insects.

INSECTS.

FLEA BEETLES, mentioned under cucumber, sweet potato and tobacco, attack this plant.

NORTHERN TOBACCO WORM, TOMATO WORM *(Phlegethontius quinquemaculata)*; SOUTHERN TOBACCO WORM *(Phlegethontius sexta)*. See tobacco.

TOMATO FRUIT WORM *(Heliothis obscura)*. Larva bores into fruit. Fall plowing; clean cultivation; corn as trap crop.

TREES.

Timber and shade trees, in addition to many leaf diseases, are attacked by numerous fungi that grow in the wood and cause decay. Some even grow in live wood and kill it. The mushrooms or shelf fungi, seen growing from logs or from dead portions of live trees, are the fruiting organs of these wood destroying fungi; the larger part of the fungus lives in the decayed part of the wood.

Much can be done to protect shade trees by destroying all dead portions and the fruiting bodies of the fungi and painting over injuries. To some extent this can also be practiced in well regulated forests. At least dead and mature trees should be cut and used. There are various methods of protecting cut lumber of all kinds from decay, but this is hardly the place to discuss them.

Illuminating gas escaping in the ground often kills trees on city streets, and the gases of smoke in manufacturing regions seriously injure many kinds of trees, especially the evergreens, like pine and spruce.

Injuries by horses hitched to trees and by unscrupulous wire stringers, unfortunately, are too common.

There are many common pests which attack our forest and shade trees, the majority being insects that do injury by eating the foliage, in which case the stomach poison or arsenical is employed to control their ravages. There are also many scale insects that attack these plants which can be controlled by one of the contact insecticides. The oyster shell scale is doing considerable injury to the maple trees in many parts of the state. We refer the reader to Bulletin 111 of this Station for further information concerning this pest.

TURNIP.

The turnip is subject to much the same diseases and insects as cabbage. Usually none are serious.

VIOLET.

Leaf-spot *(Alternaria violae)*. Circular brown spots on the leaves. This and other violet diseases can best be controlled by growing only the strongest and healthiest plants that can be secured and keeping them under the best condition throughout the year, removing or burning all diseased parts and disinfecting the houses and beds.

Black or brown aphis *(Rhopalosiphum violae)*. Plant louse; sucks leaves. Fumigate with hydrocyanic acid gas. Seek further advice before using.

Two-spotted red spider *(Tetranychus bimaculatus)*. See geranium.

WALNUT.

Yellows. A disease somewhat like peach yellows, often causes bunches of slender yellowish shoots on the walnut, especially on Japanese varieties. So far, it has not proved very destructive, but is not yet well known.

WATERMELON.

The diseases are about the same as other plants of this family, such as muskmelon and cucumber. The anthracnose is the main trouble and can be controlled by a few sprayings with Bordeaux mixture. For insects see cantaloupe.

WHEAT.

Diseases.

Rust *(species of Puccinia)*. Reddish or black rusty specks or streaks often covering the leaves and stem. On badly rusted wheat the grain is shrunken and light. The only promise of control is in rust resistant varieties. Some have been secured for the western wheat regions, but none yet very good for this section.

Scab *(Fusarium culmorum)*. The central stem of the head is killed by wet weather and the fungus and the upper part dies. The fungus appears as pink or black spots on the stem or chaff. No remedy.

Loose smut *(Ustilago tritici)*. The head is changed into a black, dusty mass. Soak the seed four hours in cold water, let stand four hours in wet sacks and then immerse for five minutes in hot water. (113 degrees F.). Then dry and sow. This is only a partial preventive and may cause some injury to the seed. If possible, sow seed from smut-free fields.

Bunt or stinking smut *(Tilletia tritici)*. The injury is to the grain only which is swollen and filled with a black stinking substance, which ruins the flour if abundant. Sprinkle the pile of grain to be sown with formalin (1 part to 400 of water) until all the grain is wet, let it stand two or three hours, then dry and sow.

INSECTS.

WHEAT JOINT-WORM *(Isosoma grande).* Larva works at joints in stem. (Fig. 37.) Plow down or burn off stubble.

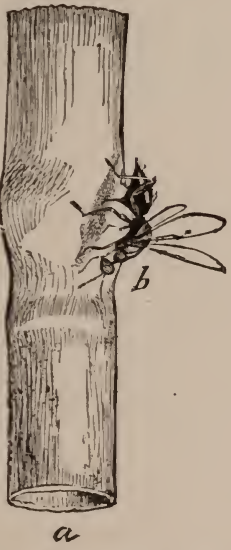

Fig. 37—The Greater Wheat Joint-worm. Female ovipositing in wheat-straw. (After Riley.)

WHEAT LOUSE *(Nectarophora avenae).* No practical remedy. Natural parasite (Fig. 38) usually. Ten per cent. kerosene emulsion would control pest if possible to use.

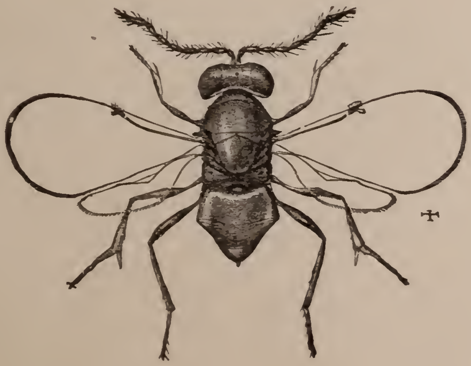

Fig. 38—Parasite of the Grain Plant-Louse. (After Howard.)

HESSIAN FLY *(Mayetiola destructor)*. Larvæ injure stem of plant. Plow or burn stubble. Sow wheat late in fall, after frost.

NOTICE.

If further information is desired about any insect write to the Entomologist, College Park, Maryland; or, if information is desired concerning any disease of plants, write to the Pathologist, College Park, Maryland. If the insect or cause of the disease is not known, samples can be mailed to the above address for identification. Information is furnished free of charge.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

BULLETIN No. 116. MARCH, 1907.

MARKETING FRUIT AND TRUCK CROPS.*

BY W. N. HUTT.

INTRODUCTION.

The most obvious development of mercantile methods in the last decade is seen in the preparation of products for market. With pristine merchants, tea was tea and soap was soap. They bought in bulk and measured or weighed out the quantities desired by their customers. The goods came in barrels and hogsheads and went home in the various baskets and boxes of the purchasers. With the merchant of today the bulk article is almost unknown. His shelves, cellars and refrigerators are stored with divers small cans and boxes and packages under numberless labels and trade-marks, each containing a definite amount of some varied commodity of home consumption. Times have changed, so have men and methods. The recent Pure Food Law is an evidence of the approaching millennium.

Modern commercialism offers no more interesting phase than the almost infinite modifications and numberless varieties of the few staple necessities of human consumption. Indeed, nowadays, one would be much surprised if at breakfast he were not served with some new variety of breakfast food of magic muscle and brain-building power. There is no better example of man's inventive genius than the kaleidoscopic variety of his food products.

The marketing of horticultural products has followed pretty closely along the same mercantile lines as general food products. New types and varieties of native fruits have of late years largely increased. Extended communications by land and water bring to even our local markets the varied horticultural products of the whole world. New and strange fruits are seen in our stores almost daily. One may breakfast on fruit of the orient, dine on products of the antipodes and sup on salads of the occident. All these are brought to our doors by recent improved methods and facilities in transportation and marketing.

While horticultural products have largely increased in quantity and number, the containing crates and shipping packages have by modern requirements been largely unified and reduced to definite standards. The peculiar heterogeneous baskets and boxes and crates that used to carry fruit to market are scarcely ever seen today. Their places have been taken by a few standard packages. As with general merchandise, the bulk method of marketing horticultural products has almost entirely disappeared. Greater quantities of fruit, than ever before, are now marketed but they go to market in much smaller packages than formerly. With tender fruit of high quality the hogshead and barrel package has almost disappeared from our markets. With even hard, winter apples the bushel box is rapidly displacing the larger barrel. Strawberries used to be shipped in 56 and 60-quart crates but now the best kind of berries in such a carrier would go begging for a customer. Plums, peaches and grapes are now sold in packages much smaller than those formerly used. This decreasing of the size of the package in which fruit is sold has enormously increased the consumption of fruit with all classes of people. Many who could not afford a barrel will readily buy a box or basket, especially since the box or basket is light and portable and does not need to be returned. Thus the gift package in selling fruit has become almost universal and being made of very light wood or veneer it costs comparatively little to the grower. There seems to be an increasing tendency in the fruit trade to sell fruit in packages that a man can take home in the hand.

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* The data for this bulletin was collected previous to Professor Hutt's resignation, October 1st 1906 to accept a position at the North Carolina Experiment Station, but the manuscript was not turned in until March 1907. H. J. P.

BRANDS AND TRADE-MARKS.

The use of trade-marks and labels is not entirely a modern practice; it had its origin in the past but this is its golden age. A trade-mark is a sign of honesty. The man who stamps his goods with his own name, or business crest, shows that he is not ashamed of them and the purchaser feels it a sort of guarantee of quality. True, there are spurious trade-marks glued on with intended deception, but the counterfeit only more surely proves the reality of the current coin of the realm. In spite of the questionable methods of some modern merchants who make undue haste to be rich, the world is getting better and modern business methods are purer and better than ever before. The recent Pure Food Law will doubtless be instrumental in purifying our food products and in eliminating dishonest brands and trade-marks.

Many old trade-marks in use today have come down to us through the centuries, to mark the honesty of their originators. The word "Sterling" which today marks the purity of our silver was the name of a firm of Flemish merchants, the Sterlings, who were noted for the purity of their money in an age when debased coin was notoriously common.

Horticultural products have always been noted for their purity. Many careful growers of fruit have worked up a special fruit trade by shipping high-class fruit under their own brand and name. In years when climatic and other conditions render the quality of fruit lower than the grade they are accustomed to ship under their named brands, the fruit is forwarded unbranded. A neat attractive brand or label on well-packed fruit soon becomes known and asked for on the market.

A brand should include besides the name and address of the grower, the variety of fruit contained in the package. The general trade brand can be kept in stencil form for head of barrel or box with an insert to show the variety. With basket fruit, like peaches or grapes, the variety name may be put on clearly with a rubber stamp. If the variety is good the customer often wants to know the name of it so that he can get more of the same kind. The best goods in commercial lines are sold under brands containing the name, location and trade-mark of the maker. It is a business principle that the buying public soon comes to understand. They know that if a man puts his name and address on his produce he is not ashamed of its quality and it is safe to buy such produce. The best growers and shippers of fruit today are making use of this same business principle. I do not believe there is a more important factor in successful fruit-growing than the proper packing and labeling of fruit.

THE RETAIL FRUIT TRADE.

It is safe to say that of the numberless cars and cargoes of fruit that go to market by far the largest part of it goes to the consumer through the hands of the Italian fruit vender. He takes to the retail fruit trade by nature as a Chinaman does to laundry work or a duck to water. His education and temperament adapt him to the fruit stall or push cart just as naturally as fins fit a fish for its native element. One cannot board a railroad train or steamboat but he must pass the alluring wares of the "Dago" fruit vender. In this apparently small way the products of millions of vines and fruit trees find their way to a profitable market. There are thousands of these Italian stall venders and push cart men in our large cities and they are rapidly finding their way to and establishing themselves in our large towns. His stall or cart is the final clearing house for the fruit trade and shippers who would be successful must reckon with the requirements of this king of the market.

The "Dago" vender is very rigid in his requirements of the fruit he will buy. He knows that fruit sells on its appearance and will buy nothing that does not look attractive and therefore salable. He wants only the freshest of fruit or that which will stand up well and give him plenty of time to sell it before it becomes soft. He wants perfect fruits of uniform grade, for he will not have culls or small, defective specimens left on his hands at a loss. He deals most largely in bananas, oranges and the firm, dry, highly-colored fruits of the Pacific Coast for they conform most closely to his requirements. The Italian vender is such a powerful factor in the fruit trade that his requirements are not to be disregarded. Shippers and growers can well afford to consider his standards.

As in most cases the grower of fruit cannot carry his fruit to the consumer, he must employ the railroads to ship it for him and the commission merchants to sell it on its arrival in the city. Very often these three parties are a triumvirate of discontent. My observations lead me to believe that it is because they know too little of each other's methods, but each maintains that it is because he knows too much of them. Each has at any rate an interest in the business that is well worthy of investigation.

RAILROADS IN RELATION TO HORTICULTURE.

The railroads have always been the scapegoat from both sides of the business, and I cannot refrain from saying a word in their favor, even though they are pretty well able to take care of themselves. Following the pioneers of commerce, railroads have been the most active agents in the developing of the country; greater than armies and navies, greater perhaps than our universities. With most of the great railway corporations their interest in horticulture is more than a passive one. Many railroads are paying trained horticultural experts to develop the fruit and truck raising along their lines. Only this summer I lost a valuable assistant because the railroad could afford to pay him more for horticultural work than the State could. They are doubtless looking after their own interests, but they pay men to help the grower to help himself. It is very easy for the grower to throw the blame for his lack of success on the railroads or on the commission men. Undoubtedly the railroad people and the commission men are not all good, as are the growers not all good, but at any rate I believe they are human.

DISHONEST PACKING.

Some growers and packers of fruit are really very unfortunate, for nature herself seems to be against them. On some farms the laws of gravitation seem to be reversed and the large fine apples gravitate to the ends of the barrel, and the little, gnarly ones gravitate to the middle. Such men are unfortunate, for it is of them that the Scripture says, "They are like the chaff that the wind driveth away." But there are many honest growers who take good care of their orchards and spray well and pack honestly that are unsuccessful because they do not know the market and its requirements.

MARKET PROBLEMS.

Let us look at some of the market's problems. First in importance is what market to send to, when to send to it and what to send to it. Some markets will take a product that others will not have. For example, Porter apples will sell well in Boston but are not wanted in New York. Tolman (Sweets) bring good prices in Philadelphia but can scarcely be given away in Rochester. Some people think brown eggs are richer than white eggs. Some markets will buy only white-skinned poultry while others want only yellow-skinned. Some consumers believe red apples are of higher quality than those of other colors. A grocer in a certain city told me that that was a black tea town and that one could not get the people there to use Japan tea if one gave it to them. He was a wise merchant and kept only black tea and did not try to make his customers take what they did not want. It is hard to educate public taste. It always pays the fruit grower to study the demands of the market and to give people the kind of fruit they want.

When to send to a certain market is a still more difficult question than what to send. The wind itself is scarcely more fluctuating than market prices. You see in today's paper that there is a shortage of fruit in a certain market, you send there heavily expecting to find a good market, everybody else does the same, and tomorrow sees a glut in that market with slaughter prices. Such a glut occurred in New York market last summer with vegetables and the stuff could scarcely be given away by the commission men. The only safe way to watch the market is to have one's finger on the wire.

The growing of good fruit is of course fundamental to the selling of good fruit. Formerly, growing and selling were all one business. In the early days, the farmer raised his fruit with little molestation from insects and fungi, placed it in his wagon and took it to market to his customers. The business was soon over and he came home with necessary supplies obtained in barter for his fruit. But "the good old days" are past, and now to have any fruit at all the grower must give earnest and intelligent attention to the insect and fungi sides of the business. These are homonymous and also synonymous with insecticide and fungicide. Indeed, nowadays the successful fruit-grower has become, under the instructions of Colleges and Experiment Stations, a practical entomologist and pathologist. He finds that unless he knows the habits of insects and of fungous diseases and also the means of checking or averting their attacks he is in a losing business. He cannot take his fruit to market as formerly for the centers of population have moved far from the farm or vice versa, so he must consider the packing, shipping and marketing sides of the business.

Too often the grower of fruit sends his produce by an unknown route, to an unknown people, in an unknown market. The result is well known, for it becomes a frequent topic of conversation with neighbors how he is cheated by the railroads and the dishonest commission men in the city. Often the farmer packs his fruit as well as he knows, often too, not as well as he knows, but without a knowledge of the market and its requirements he seldom gets a first-class price.

Marketing is almost a science in itself. Many farmers can grow fruit while but few can market it successfully. One can learn many valuable things about markets from shrewd observations from the outside, but to really know the selling business one must look at it from the inside. Few growers have the opportunity to look on the market business from the inside therefore they have many painful experiences. Experience is a very good but also a very expensive teacher. One of the most successful fruit growers I know of makes annual trips to the large cities to look into market conditions. Heretofore the trained experts of Agricultural Colleges and Experiment Stations have given nearly all their attention to the problems of the growing of fruit to the almost entire disregard of the market side of the business. Growers often tell me that they can raise good fruit but they often fail to market it profitably. Some growers claim that there is an over-production of fruit. What they call over-production is really want of distribution, for there can be no absolute over-production while there are people hungry for fruit and ready to pay for it.

COMMISSION MERCHANTS.

Most of the general fruit that goes to market is sold by commission merchants. These merchants receive the fruit consigned to them, and on selling it charge the consignor usually 10% of the selling price and remit the balance less charges for freight, drayage, &c. Properly handled, this method of marketing fruit gives very good results. I know of a case where a fruit-grower has sent all his fruit to one commission man for the last twenty-one years to the mutual benefit of both. After this long-standing business relation of fruit-grower and commission man each respects the other. But such a case is the exception rather than the rule. One too often hears the commission man spoken of by the fruit-grower as a rascal, while the commission man regards the farmer as a most shiftless business man. There is much to be said on both sides, but it may safely be said that selling by commission is a loose method of business when regarded from the interests of the consignor. In the first place the commission man bears no risk, as the fruit is the property of the consignor till sold and the latter carries all risk and bears all losses. The commission man has usually little or nothing invested in stores or warehouses for his consignor's fruit. Often he sells the fruit by auction or private sale from wharves or railway platforms in which he has not a cent's worth of interest, or uses the public streets and pavement before his small shop. The sender of the fruit has only the commission merchant's word for the price at which his fruit or truck sold. This is certainly a loose method of business and gives great opportunity for fraud and has often been taken advantage of by dishonest merchants. This fact has branded the whole commission fraternity as "Thieves and robbers." However, honest merchants by their commission leagues and societies have found means of shutting out dishonest men from the business, yet it is easy to see that the advantages of commission selling are largely in favor of the consignee rather than of the consignor.

A great deal of the adverse criticism and even opprobrium that is cast upon commission merchants for small returns is often due to the growers' carelessness, lack of business ability or lack of knowledge of market conditions. Let us take these up separately.

GRADING FRUIT.

CARELESSNESS IN PREPARING FRUIT AND TRUCK PRODUCTS FOR MARKET.

To see the way in which some fruit comes to market one would not wonder that there are farmers who say fruit growing does not pay. Not infrequently baskets give evidence from their blackened, mouldy appearance that they have been stored in damp cellars or they show the chaff and dust of the hay loft. Such packages could not bring a good price for even the choicest of fruit. Second-hand packages or those that have been used for fruit before, besides being unsightly, will cause fruit to decay on the road to market. The wood of second-hand packages becomes impregnated with the spores of moulds and rots from former fruit and will cause the speedy decay of fresh fruit coming in contact with it.

Not infrequently packages are used which are unsuited to the nature of the fruit. A bushel basket is a poor means for carrying and displaying delicate, high-class fruit like peaches. A barrel is too large for soft fruit like Bartlett and Clapp pears. Often a 20-lb. basket of grapes will be begging for a purchaser while if the same fruit were placed in dainty 3-lb. baskets the fruit would sell like hot cakes at 25 and 30 cents a piece, or 8c. to 10c. per lb. for the grapes.

The most common evidence of carelessness on the part of the fruit-grower is the sending of ungraded products to market. An ungraded package showing large, intermediate and small specimens of fruit almost invariably sells at the rate paid for inferior stuff. It would probably sell at a better price if every specimen in the package were small, the large specimens being a detriment rather than otherwise. It is a frequent sight in the commission houses of any of our large cities to see men sorting and repacking fruit carelessly put up by the farmer. The commission men pays the farmer a minimum price for the whole package, and that is the best that can be gotten for it. The large fine specimens are sorted out and packed in a smaller package and bring a special price, often much greater than could be gotten for the whole original ungraded package. The profit for such grading which might have gone to the grower, naturally went to the commission merchant who did the work. The farmer, moreover, paid the same freight on the inferior fruit in the package that he did on the special grade that brought the special price to the commission merchant. Figure 1 shows a good type of machine grader. This greatly reduces the labor and cost of grading. Defective specimens are removed from the graded fruit as it is put into the packages.

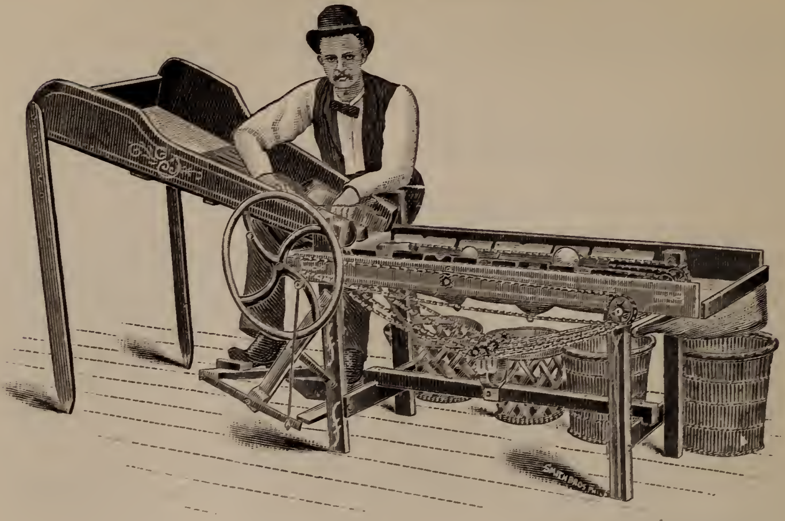


Figure 1—Machine Grader.

Selling fruit is a very different business from the growing of it. There are a great many more men who can successfully grow fruit than there are who can profitably market it. The marketing of fruit is a special business by itself. The successful production of fruit requires knowledge of growing conditions; the profitable marketing of it requires knowledge of selling conditions. Few men are able or are in position to know thoroughly both ends of the business, thus the need of the commission man.

Some commission men even take the trouble and expense of sending an advance market sheet to advise their clients of the state of the market. The following is quoted from one of these reports:

MARKET REPORT.

Buffalo, Thursday, August 24th, 1905.

APPLES AND PEARS.

APPLES—Receipts are increasing, but the demand is active for anything above common and that class sells also at much higher prices than usual. In fact, so far apples of all kinds have brought more money than expected.

Red Astrachan, No. 1, per bbl.	2 50@3 00
Strawberry, do	2 75@3 00
Duchess, do	3 00@3 50
Sweet Bough, do., fancy	2 75@3 00
Golden Sweet, do	2 25@2 50
Common, green, per bbl	1 50@2 00
New York State, fancy 1-3 bu.	45@ 50
New York State, fair to good	30@ 40
New York State, per bu	50@1 25
Crab Apples, per basket	15@ 20

Pears—Some good pears are beginning to arrive and there will be no difficulty in disposing of choice to fancy around quotations. Bartletts and other varieties in dinky measure boxes are not in favor in this market, and especially at the high prices at which this rather inferior fruit is being held.

Pears, Bell, per bbl.	1 75@2 00
Pears, Sugar, per bbl	2 00@2 25
Pears, Bartletts, per bbl	3 50@4 00
Pears, Clapp's F., per bbl.	3 00@3 25
Pears, Tyson, per bbl.	2 50@2 75
Pears, Clapps, F., 8-lb. basket	20@ 25

PEACHES.

The first really fancy peaches in several weeks arrived yesterday from Michigan and selections brought the highest prices in years. Fancy fruit was badly wanted and all of that class cleaned up quickly. There were, however, only a few baskets above good in quality, but all cleaned up readily at much better prices than expected. Home-grown are in abundance and selling at such a wide range that it is impossible to quote the market. The glut of early fruit is the worst in years and it will take low prices to move it.

Ohio, peck basket	20@ 30
N. Y. State, small basket	15@ 20
N. Y. State, 1-3 basket	30@ 40
Michigan, yellow, fancy bu.	2 00@2 50
Michigan, white, per bu.	1 00@1 75
Michigan, fair to good, do	1 50@2 25

GRAPES.

Receipts are increasing and quality is greatly improved. The best lots sold readily at quotations, but there is quite a supply of common stuff still on the market.

Moor's Early, 8-basket carrier	1 00@1 25
Champion. 8-basket carrier	75@ 85
Niagara, 8-basket carrier	1 25@1 50
Hudson River, pony baskets	12@ 15

BERRIES.

Huckleberries—Unsalable except at very low prices. Offerings are quite heavy, considering the slow trade, and the outlook is for still lower prices.

Blackberries—Early receipts clean up easily at good prices.

Blackberries, Lawtons per qt.	10@ 12
Blackberries, medium, per qt.	8@ 9
Blackberries, wild, per qt.	10@ 11
Huckleberries, per quart	5@ 7
Huckleberries, per 12-lb. basket	40@ 60

PLUMS.

Receipts were very heavy, dealers being swamped, and even at the low prices prevailing it was impossible to clean up the market. Next week there will be a cry for plums and buyers will probably pay a good price.

Plums, red, 7-lb. basket	10@ 12
Plums, yellow, do.,	10@ 12
Burbanks, per 7-lb. basket	10@ 12
Michigan, per 7-lb. basket	12@ 15
Niagara, per 7-lb. basket	12@12½

MELONS.

Muskmelons—It's the old story of poor quality. The expectation was some improvement in that respect, but even home-grown has shown up more than usually poor. The hope is that next week's receipts will change the general complaint.

Watermelons—Good steady trade for ripe, but there is only a moderate supply of that quality, and far more of the undesirable than can be sold at much above freight charges.

Muskmelons, fancy, ⅌ crate	1 50@1 75
Muskmelons, fair to good	50@1 00
Muskmelons, R. F. Stand., crate	5 00@5 25
Muskmelons, R. F. pony	4 00@4 50
Muskmelons, Ind., per basket	20@ 30
Muskmelons, H. G., per basket	40@ 50
Muskmelons, Osage, per bu.	1 50@1 75
Watermelons, large, ⅌ 100	22 00@25 00
Watermelons, medium, do	18 00@20 00
Watermelons, small do	14 00@16 00

POTATOES.

A slight scarcity, due to rain at outside shipping points, caused a stronger feeling here, but it was only momentarily, as there is a world of potatoes again this year, and the market is plentifully supplied today, with every prospect of prices going lower next week. Home-grown are of excellent quality, and will probably supply the demand in this section from now on.

Fancy, per bbl	1 75@1 80
Fair to good	1 50@1 60
Culls and common	75@1 25
Home-grown, fancy, per bu.	60@ 65
Home-grown, fair to good, do	50@ 60

Sweet Potatoes—Few offerings of desirable and inquiry active. Plenty of common to fair and small stuff which buyers do not want.

Sweet, Virginia, fancy, bbl.	2 25@2 30
Sweet Virginia, fair to good	1 50@1 75
Sweet, Jersey, fancy, ½-bbl.	1 50@1 75
Sweet, Jersey, No. 2, ½-bbl.	1 00@1 25

ONIONS.

Little interest at present; home-grown are coming in liberally and selling at quotations. Quality is only fair so far.

Onions, Spanish, per crate	1 10@
Onions, Ken., No. 1, per bbl	1 40½1 50
Onions, do., No. 2	1 00@1 25
Onions, H. G., per bu.	50@ 55

VEGETABLES.

Beans—Very irregular; shipping demand light and prices are lower.

Cucumbers—Pickles are wanted; little demand for large and supply liberal.

Cabbage—Market easier on steady, increasing receipts.

Celery—Weak; heavy supply.

Peppers—Lower; receipts excessive at the moment.

Eggplant—Irregular; some shipments worthless and plenty of fancy at low prices.

Squash—Liberal receipts; good demand.

Tomatoes—Market flooded with red at easy prices while pinks are scarce and wanted at a premium.

Beans, yellow, per bushel	35@ 40
Beans, green, do. do	40@ 50
Beans, shell, per qt	7@ 8
Beans, shell, Lima, per qt.	10@ 12
Cucumbers, fancy, per bu	40@ 50
Cucumber pickles, per 100	12@ 15
Cauliflower, per doz	1 25@1 50
Cabbage, fancy, per 100	2 50@3 00
Cabbage, small, medium, do	1 50@2 00
Celery, fancy, per doz.	30@ 35
Celery, fair to good	15@ 25
Celery, Kalamazoo, per doz	10@12½
Eggplant, per dozen	25@ 40
Peppers, per bbl.	50@ 60
Squash, marrow, per bu	40@ 50
Tomatoes, H. G., 8-lb. basket	8@ 10
Tomatoes, Acme, per bu.	75@ 90
Tomatoes, red, per bu.	30@ 40
Watercress, per doz. bunches	15@ 20

One can readily see the great value to the shipper of such a report sent from his commission man who is in touch with the latest market conditions. It has much more value than a general newspaper report. The brief, forceful notes in this report by the commission man on the quality of produce, should be eloquent to the grower who has produce to sell.

After a shipper has found a good reliable commission man in a certain market it generally pays better to send to that man exclusively rather than to divide consignments amongst different merchants in the same market.

THE NEW YORK FRUIT EXCHANGE.

The most up-to-date fruit selling association that I have ever seen is the New York Fruit Exchange which has its head office at 81 Beach St., New York City.

As a forwarding and selling association the New York Fruit Exchange is unique. From its head office it keeps track of all car and ship-loads of fruit from the time of loading till they are placed in any market. By means of a blanket rate a car of fruit from the west to New York may be diverted en route to Philadelphia, Pittsburg, St. Louis or elsewhere, wherever the market promises best. By telegraphic communication it is known several days or a week beforehand just when large consignments of any fruit may be expected to arrive and bulletins for the use of members are posted accordingly.

Small consignments of fruit are exposed and sold in the show rooms of the exchange. Large consignments are sold at the dock on arrival. The fruit is brought to the Erie Pier by boat-load or cars, run onto ferries, which unload from ships directly to the wharf. All fruit consigned to the exchange is received by its agents and placed on the wharf, and a few boxes of each opened for inspection. If a car is composed of mixed lots, each lot is placed by itself, and given a number. All the fruit consigned for the day is placed in position and

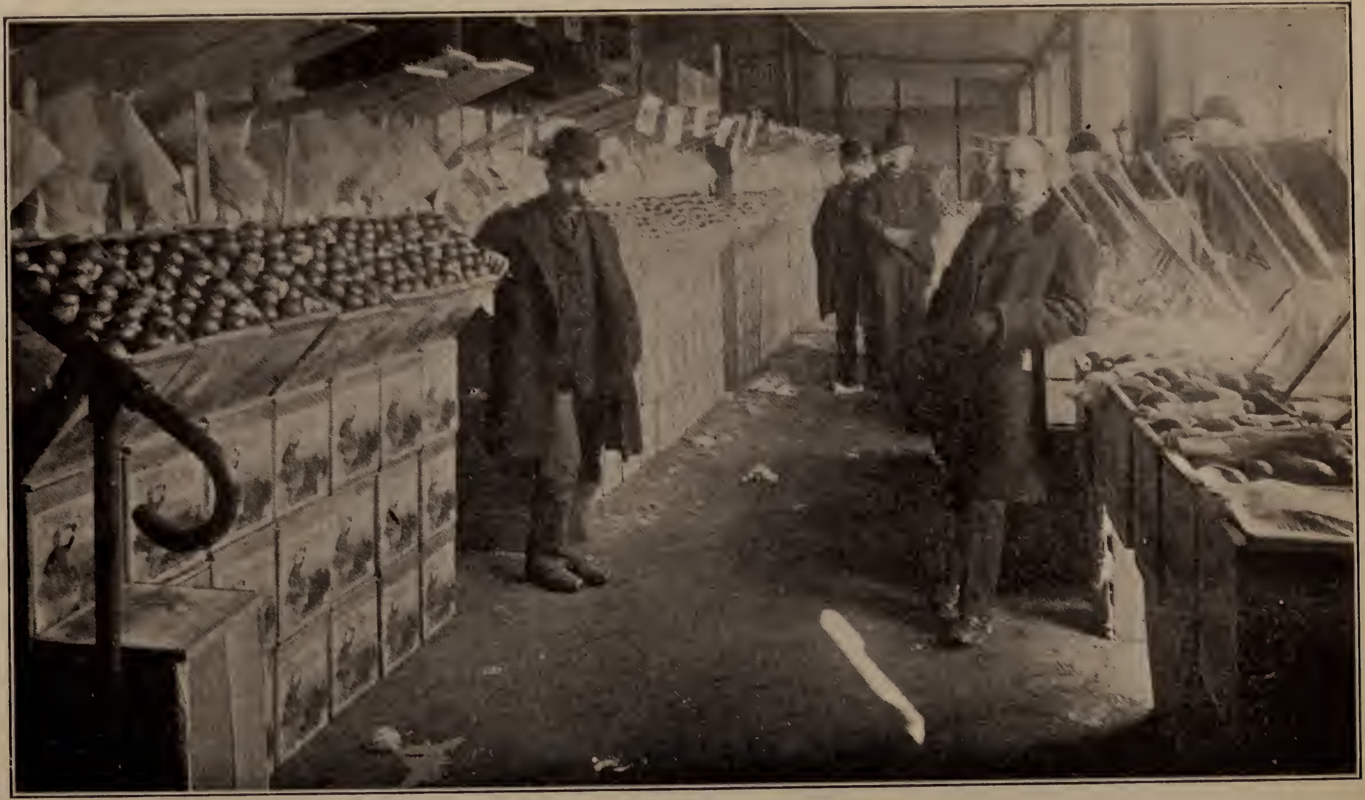


Fig. 2—Scene at the New York Fruit Exchange.

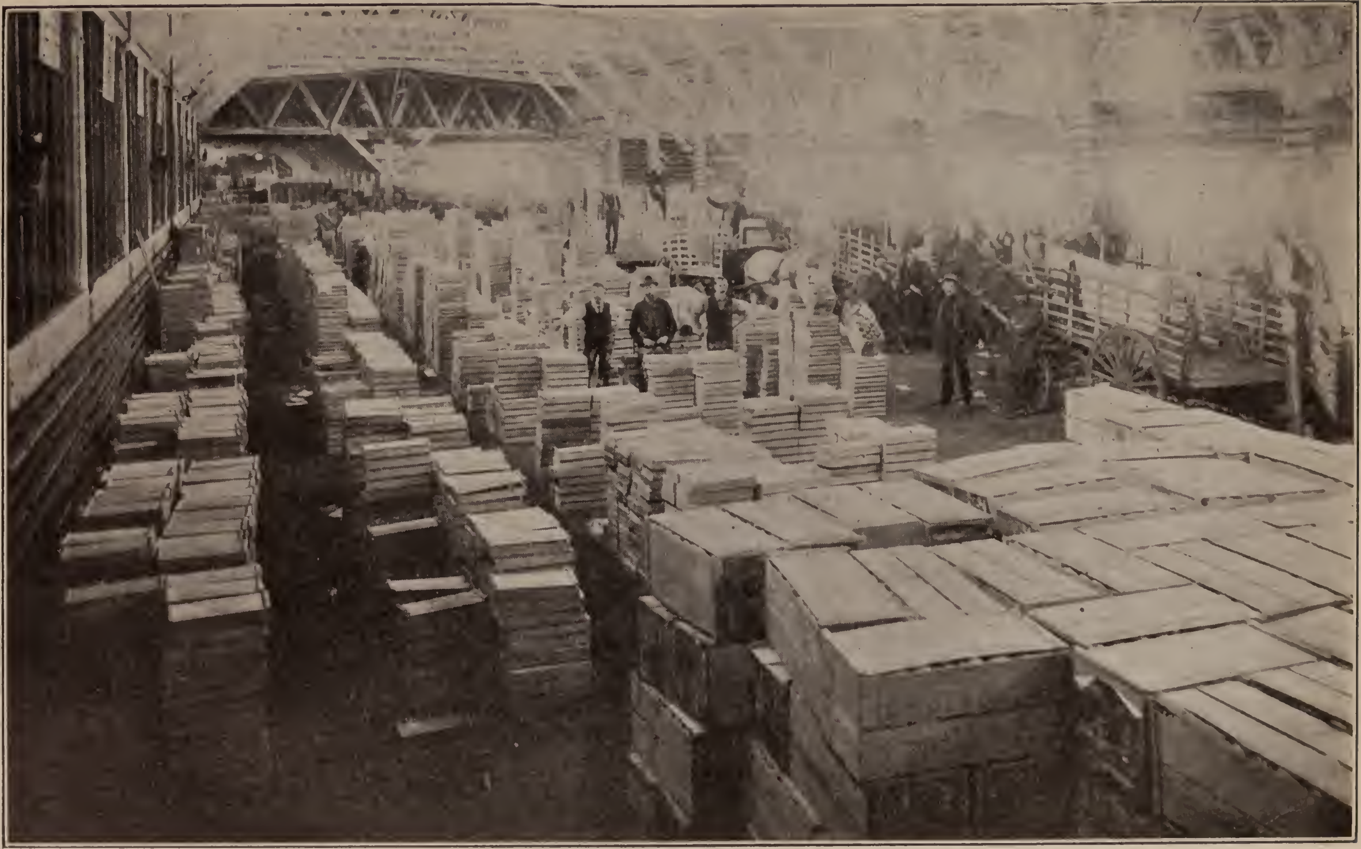


Fig. 3—The Wharf of the New York Fruit Exchange.

narrow aisles left so that the buyers may go up and down and inspect the fruit to be sold. Often the whole wharf is covered. Figures 2 and 3 show views of the Exchange's wharf. After the fruit is in position, dock inspectors make a report for publication of the condition of all fruit before selling begins. This obviates complaint after the fruit is sold and gives the consignor recourse in case of the old trick where good fruit is bought for a song by reporting that it had spoiled in transit. It also protects the buyer if fruit turns out other than what the opened boxes showed. Everything is sold on inspection. From the way-bills, the notes of the Exchange's agents unloading the cars and the numbers placed on each different lot of fruit on the wharf, a selling catalogue is made. One of these is given to each buyer as he enters the wharf. On these the buyer may make his notes on what he wants to buy and what he cares to bid on. At 9 A. M. a bell is rung and the sale, by auction, of the entire day's consignments begins in the large auditorium above the wharf. A firm of fruit auctioneers has its office in the building. The buyers are almost entirely Italians.

To hear the foreign language used as the selling proceeds, one could almost imagine himself in sunny Italy. The buyers are allowed to call for consignments they particularly desire. The bidding on choice lots is often as noisy as on the Stock Exchange. Clerks are on hand who record in the printed catalogues the prices as each consignment is sold. Reporters publish the catalogue and sales in the fruit trade journals. A shipper in California, who uses the exchange, can thus know the exact price for which each lot in his consignment was sold. This puts the selling on a perfectly open basis and the shipper does not need to depend on the word of any commission man. This, together with the condition report mentioned above, makes the Exchange a safe concern for both buyer and seller.

COOPERATIVE FRUIT SHIPPING.

Perhaps the greatest aid to successful fruit production today is cooperation. Many small lots of good fruit are sacrificed in the wholesale market of our large cities because they are lost sight of in the great bulk of stuff arriving. Large consignments receive consideration that is scarcely worth while to give to a few odd boxes or packages. It would be a great advantage in shipping if the growers at one point could cooperate and send their fruit not as small individual consignments, but as car lots. Commission merchants are glad to come to the growers and buy at the railroad if they can buy from a company, society or exchange, but they have not the time to hunt up growers to buy small lots. An association of growers can employ an agent to keep in telegraphic touch with market prices while few individual growers can. An association can secure uniform grades of fruit and can do a large business under a known brand. Baskets and fertilizers can be obtained by shipping associations at wholesale prices. Cars, rates and concessions can be obtained from the railroads by an association that no single individual could hope to receive. There are many successful shipping associations throughout the country. Below is given a few types of these associations or exchanges. The following from "The Fruit Grower," of St. Joseph, Mo., September, 1906, gives a type of association found successful in the west.

WATHENA FRUIT-GROWERS' ASSOCIATION.

"Early in 1905 a few of the growers met and decided that the thing to do was to organize a shipping association, and handle their own fruit and buy their own supplies. As a result the Wathena Fruit-Growers' Association was organized, and the first year the new organization had but twelve members. The firms which had previously handled the fruit of the growers claimed that the new association could not last; that farmers could not market their fruit to advantage, and all sorts of hindrances were put in the way of the association, in the form of extremely low prices for fruit packages, and unwarranted high prices for fruit at critical times—this being done to discourage the members of the association, and to entice them away from their organization.

The first year the organization did fairly well, but the members gained much in experience. This year, the second season of its existence, the association has made a splendid record. The organization has 100 members.

The association has bought all the material needed by its members, effecting a considerable saving. For instance, growers near St. Joseph paid 6 and 7 cents apiece for one-third bushel baskets in which to ship peaches; members of the association at Wathena paid 5 cents for the same packages.

At the beginning of the season every member signs a contract to market his fruit through the association; if the St. Joseph market offers a better price, he is to receive the consent of the manager before he can take his fruit across the river. This consent, however, is not withheld unless the association needs the fruit to finish filling a car which has been sold.

The association sells practically all its fruit on track, although it sometimes happens that small quantities left after filling cars are consigned to reliable firms. After the manager knows the price to be received for a car of fruit, he makes the "platform price" to the grower accordingly. This platform price is usually about 25 cents a crate less than the price the association receives. Suppose a carload of strawberries has been sold at $1.50 a crate; the platform price will be $1.25 a crate, and every grower who delivers fruit which passes inspection receives a ticket entitling him to $1.25 a crate, which can be collected by him when he chooses. The next day a car may be loaded at $1.75 a crate; then the platform price is $1.50, and the growers receive credit for the fruit delivered at that price per crate.

When the strawberry season is over the expenses of the association in handling the crop are deducted from the 25 cents profit retained on each crate, and the remaining sum is apportioned to the growers who furnish strawberries, according to the original sums they received as the platform price.

This same plan has been followed through all the season. This plan differs from that of the Paonia (Col.) Association, for that association waits until the end of the season, and apportions the returns, after deducting 10 per cent. for expenses. But that association markets the bulk of its crop in carlots and at about the same time and prices, for Elberta peaches and apples comprise the principal shipments. If this plan were to be followed by the Wathena Association, the man who secured early berries which sold for top prices would be on the same level with the man who had medium-season fruit, when prices were at the lowest point. Where fruits are being marketed over a long period, the Wathena Association managers believe their plan is the best that can be found, for then every grower's fruit sells at the price which is ruling when his fruit is ready. The platform price varies with the price at which the fruit is to be sold, but this platform price is the same for all berries delivered that day, so that while one car of berries may bring a higher price than another car of the same grade, all growers who delivered fruit that day are on the same basis.

"But suppose a car of fruit arrives in bad shape; on a long-distance shipment?" We asked Mr. M. Boeh, president of the association. "Who stands that loss?"

"That loss is borne from the fund of 25 cents which is retained as profit on each crate. This platform price, you will note, is the minimum price, and the 25 cents retained carries the expense and bears the losses sustained through the season."

To show how this plan works, the association marketed 7,000 cases of strawberries the past season, the crop having been cut short by dry weather. The bulk of this fruit sold at a platform price of $1.50 a crate, and $1.25 a crate was the minimum. After the strawberry season was over, and all expenses had been paid, the growers received an additional apportionment of an average of 12½ cents a crate, this being the sum remaining from the 25 cents a crate retained by the association. This is a remarkably fine record, showing that the expenses of the association were much less than 10 per cent. on the strawberry deal.

More than 9,000 cases of raspberries were handled, and the minimum price was $1.75 a crate. Over 15,000 crates of blackberries were sold; the market opened at $2 a crate, and the bulk of the crop was sold between $1.50 and $1.25 a crate, the latter being the minimum. On the St. Joseph market, where growers sold to local shippers, blackberries were selling at 90 cents and $1 a crate, while the same fruit was being marketed through the Wathena Association for $1.25 net to the grower. When one considers that about 2,000 crates a day were being sold by the members of the association, at an extra price of about 25 cents a crate, one can realize what the association has been worth to the growers in handling the blackberry crop alone. They saved $500 a day.

Of cherries the association handled 810 cases, and 703 cases of plums. At present peaches and grapes are being shipped in great quantities. In the ten days preceding August 29 the association shipped under refrigeration 17 carloads of grapes, averaging 2,700 baskets to the car, and 6 carloads of peaches. In two days 4 cars of grapes and 2 of peaches were sent out, at profitable prices, which shows up pretty well for an association only a little more than a year old. The association will handle at least 20,000 barrels of apples of high quality.

The members of the association are much encouraged, and have seen the necessity of maintaining their organization. Greater quantities of fruit have been shipped from Wathena than ever before in a single season, and at a time when all the neighboring country has good fruit crops. Notwithstanding the large crops, however, the prices received by the growers have been better than for many years, and instead of feeling discouraged, the members are planting increased acreages to fruits. Their organization has made the business profitable, when without it they were considering giving up the business.

The association guarantees its fruit. All fruit is inspected when delivered, and after that time the organization stands behind the guarantee. In order to maintain a good reputation for its fruit, the members are urged to plant varieties which will carry to market in good order.

The growers in almost any community can organize along the lines of the Wathena Association. Get a few of the leading growers to start the association; the first year discouragements will be met, but if the organization is properly managed, the next year things will come easier.

"One thing which cannot be too carefully guarded in an organization of this kind," said the manager, "is the reputation of the fruit sent out. Every grower must realize that he is a part of a mutual organization, and he must see to it that he does nothing which will injure the reputation of the association or his fruit. Each member is on his honor to pack nothing but good fruit, and it is to the credit of the members that they have established a high reputation for their fruit and their methods.

THE NORTH FORK FRUIT-GROWERS' ASSOCIATION.

The organization which attends to the marketing of the fruit grown about Paonia is known by the above title. This association has a membership of about 75, and looks after the marketing of the fruit of perhaps 25 or 30 more farmers.

This association, like many others of that part of the country, not only looks after the marketing of the fruits grown by the members, but it also handles the commodities they are compelled to buy—spraying materials, spray pumps, fruit packages, potato bags, fruit-picking baskets, corn and other things which the members need. These commodities are furnished to members at cost.

The association has a large building in Paonia, adjoining a railway siding which is used as an office, packing-house and warehouse. In addition to this central building there are a number of branch stations, used as packing-houses, for the benefit of growers living near them. Most of these branch houses have a sidetrack alongside, and each one is in charge of an experienced man, and the same rigid rules as to grading and packing fruit are in force there as at the central packing-house. During the busy season all of these branch houses and the central station are worked to their full capacity.

All fruit is packed at the packing-house. Each member of the association has a number, and all his fruit is brought to the packing-house in boxes bearing this number. We will suppose that we are packing Elberta peaches. The packers are all expert and are under the supervision of foremen and assistants, who watch carefully to see that no inferior fruit is packed. When a packer places a box of fruit on the packing table, the number of the grower on the box is noted, and every package of fruit put up from that lot bears the number of the grower. At the end of the day, when the fruit is loaded into cars we take an invoice, and every number is given credit for every package of fruit of the different grades which is put up from his fruit. At the end of the shipping season of the Elberta peaches, we sum up the sales, ascertaining the average price for the fruit of each grade, and each member is paid for the fruit he has furnished, less the commission of the association and cost of packing."

The sales of peaches are pro rated over a season. In this way there is no discrimination, and every member gets credit for just the quantity and quality of fruit he furnishes. If his fruit grades all fancy, he gets the benefit of the quality; while if his peaches are of low grade, then it has to stand on its merits.

When a member brings in fruit which is too soft to ship, and the association declines to pack it, it is placed in the boxes of the man who grew it, and belongs to him. He can dispose of it as he sees fit; he can sell to the evaporator or to the canner, or do what he pleases with it.

When the fruit is sold, it is sold by the association, and the individual members have no part in the transaction. It is necessary, therefore, that our organization be in position to guarantee the quality of all the fruit we sell. This cannot be done unless we pack the fruit ourselves. It is strange how blind one becomes when packing one's own fruit—why, it is almost impossible to see a wormhole or an imperfection of any kind. We have found it best to have the fruit packed by experts who have no interest in the matter except to see that only the right kind of fruit is put into the different grades.

At the end of the season our records show just how many boxes of each variety and grade were furnished by every member of the association, and the returns are pro rated among them. From the returns we deduct 10 per cent. commission for handling the fruit, and also 24 cents per box for the package and packing. One will readily understand the importance of trying to grow only high-class fruit, when it is realized that this charge for package and packing is as great in the case of the apples which sold for 69 cents a box as it was where the fruit sold for $1.61 a box.

PENINSULA PRODUCE EXCHANGE.

One of the best organized and managed of the cooperative selling associations that it has been my pleasure to look into is the Peninsula Produce Exchange of the Eastern Shore of Maryland. This exchange operates along the lines of the New York, Philadelphia and Norfolk and the Baltimore, Chesapeake and Atlantic Railroads. It has twenty-five local shipping points at each of which is an agent who inspects and brands the grade of produce and reports to the head office at Olney, the amounts and grades of fruit and truck received. The general manager in the head office is in touch by wire with prices in all the large markets and as soon as the daily reports of receipts and grades are wired in from his local agents is in a position to make his sales and place his consignments where the demand is greatest. The exchange spends over $10,000 annually in telegrams regarding crops, markets and prices. The capital stock of the exchange was reported in 1905 at $31,000. This was owned by the 2500 farmers who sell through the exchange. In 1905, a dividend of 7% was declared and in 1906 a 10% dividend. In addition to this a surplus was laid by for emergencies. The exchange forwards annually thousands of cars of both sweet and Irish potatoes in addition to other truck and fruit. It is reported as doing an annual business in the neighborhood of $2,000,000.

Cooperative selling associations and exchanges if properly organized and managed may be of immense value to the growers of truck and fruit crops. It gives the small producer the privilege of shipping in car lots, which today is the only economic base for commercial fruit and truck growing. It insures the advantages of a uniform grade of products. Buyers and large commission firms are willing to deal with a company, where they cannot take the time and expense to hunt up the produce of the individual grower. Many associations save considerable money to their stockkholders by the purchase of baskets and fertilizers at wholesale rates.

Like any other stock company the success of the enterprise depends largely on the loyalty of its stockholders and directors. A stockholder should not withhold his produce from the association when he can get a few cents better price elsewhere. In a season's business he would almost invariably do better to deal entirely through the organized channels of the company than to sell any of his stuff elsewhere. Local jealousies should be overcome and not allowed to impede business. A good general manager in such a company is essential, and he should be paid what he is worth. A man who can manage a million dollar business successfully and make it pay a good dividend can command the salary of a bank president and he should get it. Farmer's exchanges sometimes break up because farmer directors try to retain a $5,000 or $10,000 manager on $1,000 or $1,500 salary. These foregoing remarks give a few of the dangers to cooperative selling companies.

THE PROPER STAGE OF RIPENESS FOR PICKING FRUIT.

The fruit consumer and the fruit-grower are usually too far apart. Too often what is sweet, juicy, luscious fruit in the orchard and vineyard of the grower is on the table of the consumer an over-ripe, pulpy or partially decayed product. It is a lamentable fact that many of our finest fruits are very bad travellers and present on arrival in town, a very unattractive appearance. Many growers do not know the proper time to pick fruit; that is, the stage of maturity that puts it on the market in good condition. Very often one sees fine, large pears and peaches that are rotting when the packages are opened because the fruit has been allowed to get too ripe on the tree before picking.

Sometimes when the early market is slack there is a demand for immature fruit for cooking purposes. The first early, summer apples may be profitably picked when they get big enough for cooking. This will be while the seeds are still white and before the fruit shows much signs of coloring. The market is always looking forward to the earliest apples. Dessert and winter apples should not be picked until well colored. Those that stay on the trees late are better flavored than those picked early. Winter apples will usually keep better if allowed to ripen in the cool weather of the fall, though by this waiting there is danger of heavy windfalls. Apples should not be separated from the twig by a straight pull but by a twist upwards or sideways. The ease with which some fruits separate from the twig by a nip sideways gives a good idea of maturity. With summer apples two or three pickings are generally made. Pears should always be picked from the tree before becoming mellow and be allowed to ripen after storing. The time at which the first full-sized fruits begin to fall is the indication of proper picking time. Peaches are picked for market when they show the clear or bright colors. They should not be pinched to test maturity. The experienced picker has a way of rolling the flat of his hand over the ridge of a peach and the feel means the same to him as grain in the sack does to the miller's thumb. Plums can be picked greener than any other fruit. With plums, size is about all one needs look for, as the fruit seems to ripen as well off the tree as on it. Grapes on the other hand should never be picked from the vine till fully ripe and sweet, for they will not develop sugar and ripen after they are picked. I have known unprincipled growers to spoil the market for white grapes by shipping Niagaras before they had become ripe and sweet. Tasting is the sure test with grapes. Cherries are picked with the stems on, as soon as they are big enough, and they always have the color with the size.

A day, or even a few hours too long on the tree may mean the loss of the whole cherry crop by brown rot. Color is the shipper's test with strawberries. Raspberries may be picked as soon as they will separate from the receptacle.

PICKING AND PACKING APPLES.

All handling of the apple crop should be done with the idea of bruising the fruit as little as possible. In all apples of good quality a bruised specimen soon becomes a rotten one. Apples should be picked into bags or padded baskets and carefully rolled from these into the barrels or onto the sorting table. A very handy picking bag is made by placing a pebble in a corner of a grain sack and tying the corner by means of the pebble to one side of the mouth of the bag. This makes the bag into a loop, which may be hung over the neck of the picker. The mouth of the bag comes to the front and is held open by passing a stiff bent wire under the hem. This kind of picking bag leaves both hands of the worker free for picking. Figure 4, showing the picking of experimental apples at the Experiment Station orchard, shows one of these bags in use.

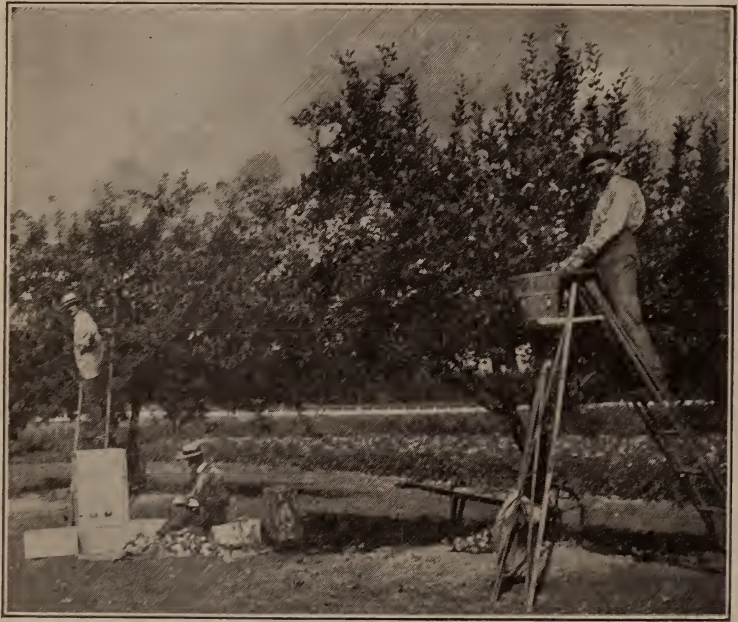


Fig. 4—Packing Apples at the Maryland Experiment Station.

In commercial orcharding it is generally most economical to have picking and packing work going on concurrently. This saves putting the apples on the ground and having to handle them again. A gang of pickers will empty their picking bags and baskets directly onto a portable sorting table placed between the rows on which they are working. This table is placed on low truck wheels and has a single whiffletree so that a horse can move it to any desired point as work proceeds. A cut of this kind of sorting table is shown in Figure 5. It should be made large enough to hold not less than two barrels of fruit. The rear bolster is higher than that at the open end so that culls can be rolled out. A long, heavy plank is placed on the ground on each side of this table on which the barrels are set for filling. The sorters pick the apples from the table into padded wicker baskets, which have low or folding handles, which permit of their being placed down into the barrel before being dumped. Apples would be greatly injured if dumped from the mouth to the bottom of the barrel. The fruit is sorted into two grades, firsts and seconds. In sorting exclude all fruits that are ripe, for if a fruit is ripe at packing time it will soon decay and spoil its neighbors. Fruits that are too green or poorly colored should be left out as they are always of inferior texture and flavor. Undersized, diseased, wormy, bruised or misshapen specimens should of course go as culls. The culls are allowed to roll into a pile from the lower end of the grading table.

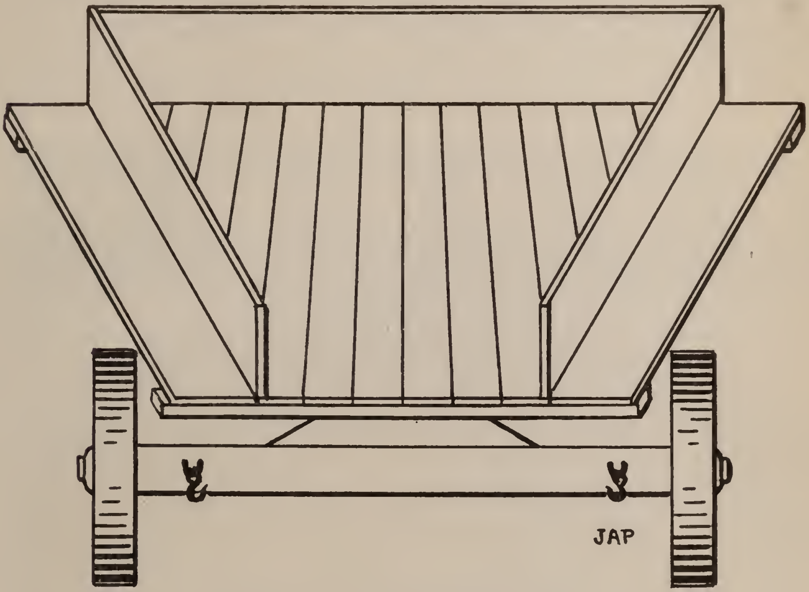


Fig. 5—A Portable Sorting Table.

The first apples placed in the bottom of the barrel should be "faced," that is placed with the stem end down. If the facing is well done, the barrel will on being opened appear as in Figure 6. If the stems are long they should be removed from this face layer so as not to cut into the skin as they are pressed against the head of the barrel. There is a small pair of nippers made that will do this work very quickly without injuring the apples. A nice effect may be made by "quartering" the second layer, that is turning the bright check so that it will show through between the apples of the face layer when the barrel is opened. It takes but little extra time of an expert packer to do this and the better general appearance of the barrel on being opened is well worth the little extra trouble. The barrel should be filled up with just the same kind of fruit as is used for the facing. It never pays to put anything but good fruit into a package. As the filling proceeds the barrel should be "racked" that is rocked vigorously back and forth on the plank. This settles the fruit into the crevices and insures a tight barrel when it is headed. "Racking" cannot be well done on the ground without the plank and the plank also keeps the heads clean and fresh from branding and labeling. Several barrels may be put on a long plank and the number of barrels necessary used for the second grade. The first grade, or No. 1, includes all apples that are of proper size for the variety, of good color, free from insects, rot, blemishes and bruises. The second grade, or No. 2, includes apples which are too small to go in the first grade, but are sound and reasonably free from insects and blemishes.

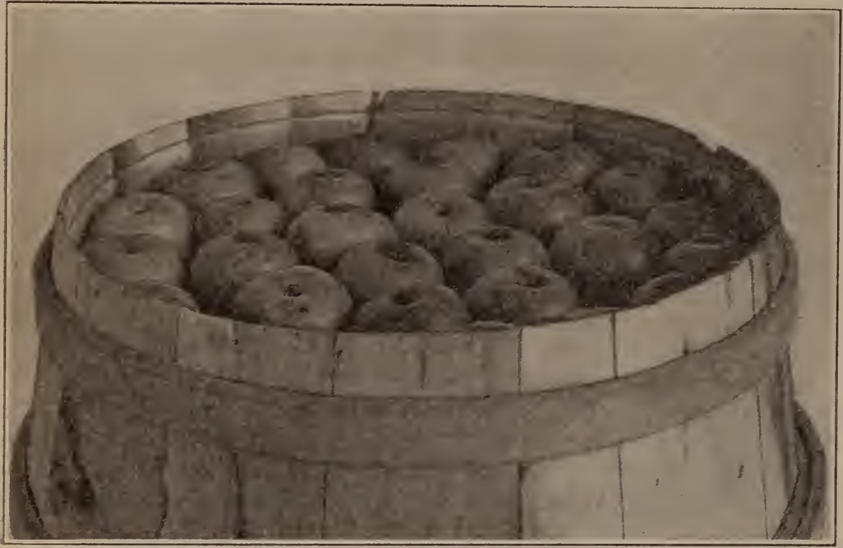


Fig. 6—The Top of a Well-Packed Barrel of Apples as it Opens up in the Market.

The following rules define the grades of apples as set down by the National Apple Shippers Association.

"Requirements for No. 1 Apples—The standard for size for No. 1 apples shall not be less than 2-½ inches in diameter, and shall include such varieties as the Ben Davis, Willow Twig, Baldwin, Greening, and other varieties kindred in size. The standard for such varieties as Romanite, Russett, Winesap, Jonathan, Missouri Pippin, and other varieties kindred in size, shall not be less than 2-¼ inches. No. 1 apples shall be at time of packing practically free from the action of worms, defacement of surface, or breaking of skin; shall be handpicked from the tree, a bright and normal color, and shapely form.

Requirements for No. 2 Apples— No. 2 apples shall be hand-picked from the tree; shall not be smaller than 2¼ inches in diameter. The skin must not be broken or the apple bruised. This grade must be faced and packed with as much care as No. 1 fruit."

Figure 8 shows a clean, even grade of apples as taken from a well-packed barrel of apples. Figure 9 shows selections made from a barrel of apples fraudulently packed.

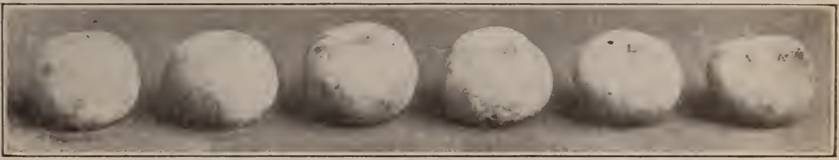


Fig. 8—Specimens from an Honestly-Packed Barrel of Apples.

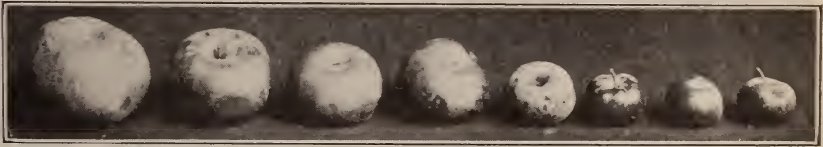


Fig. 9—Specimens from a Fraudulently-Packed Barrel of Apples.

When ready for heading the fruit should stand as evenly as possible at about ½ to ¾ inches above the chime of the barrel. A corrugated paper cap or excelsior cushion should be placed on, the head laid and the press applied. Figure 7 shows a barrel with the screw press in position ready for driving down the head. Just beneath the head may be seen the excelsior cushion. After a little experience a handy man learns lots of little knacks about heading up fruit. One of these is driving down the hoops before the press brings the head entirely down to its goove in the staves. This brings the head in place with a satisfactory snap that retains it before a nail is driven. The press is now taken off and the hoops driven down tight and nailed in a slanting manner so that the ends of the nails catch and hold the head. For export shipping it is safer to nail a couple of pieces of hoops inside of the chime as head lining. The middle hoops are now driven down and each nailed with three nails. When headed up in this way the fruit in the barrel will be tight so that it will not rattle on being hauled or moved about. Any barrel in which the fruit is heard to rattle has not been racked and pressed sufficiently in packing. The fruit becomes bruised and rotten in transportation and the barrel is known as a "slack." Every shipper knows how these slacks reduce the profit of the shipment.

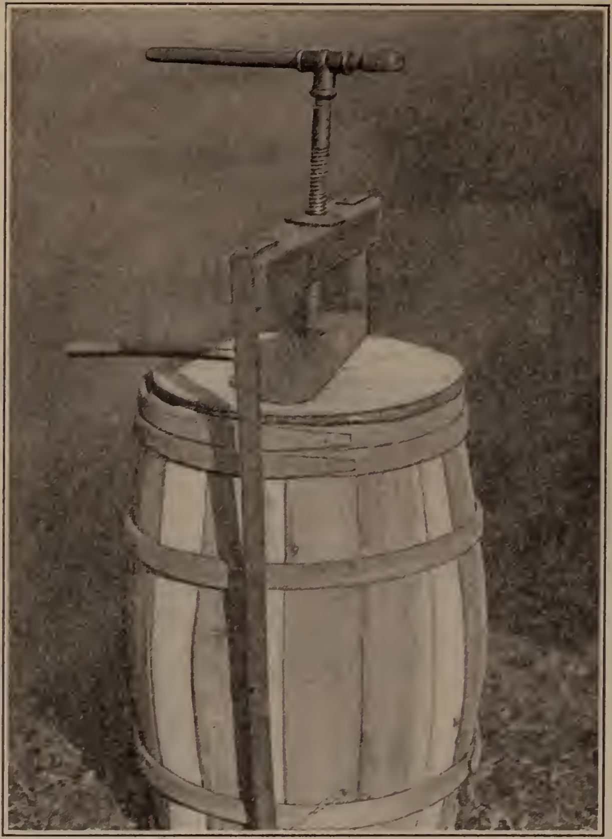
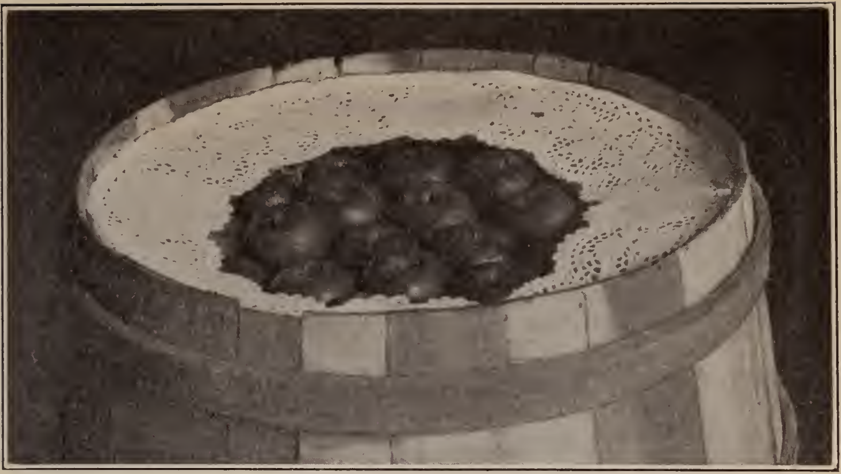
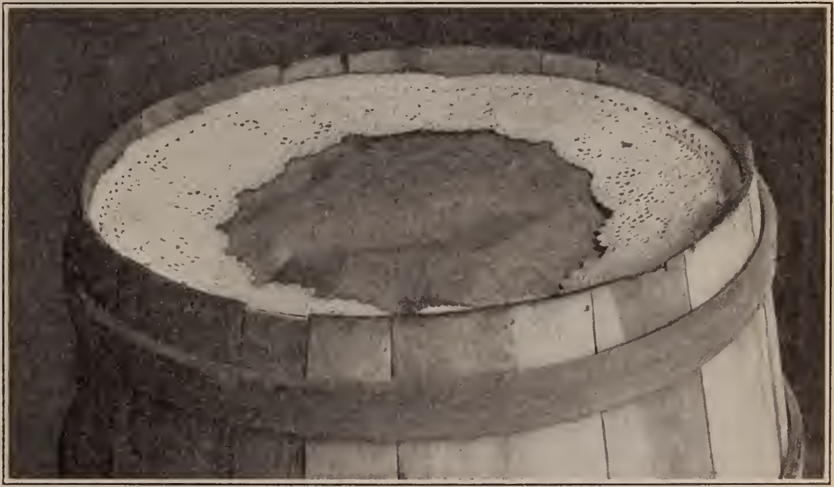


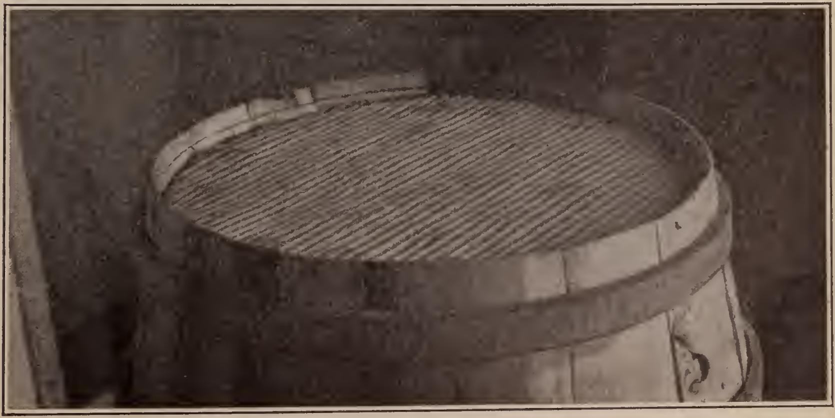
Fig. 7—Putting the Head in Place. (Note the Press and the Cushion Just Under the Barrel Head at the Right.)

Some growers use fancy paper covers, which gives the fruit a dainty appearance on being opened. Figures 10 and 11 show the fancy covers in use. In Figure 11 a paper cap is shown just beneath the cover. Figure 12 shows a corrugated paper cap, which is very useful in protecting the fruit from bruising while being pressed. This corrugated cap or the excelsior cushion should always be used in packing apples for export.

In Canada wonderful advancement has been made in apple shipping and the securing of the best export trade by the passing of a penalty law for careless or fraudulent packing. This law requires that all fruit packages shall be branded with the name and address of the grower, and give the name of the variety and the grade of the fruit. The law fixes a standard grade. The law provides for a regular system of inspection and provides for fine for neglect to conform to the requirements.







Figs. 10 to 12—Fancy Paper Used in Trimming Barrels of Fancy Apples—Winesaps in this Case. In the Lower Figure is shown the Corrugated Cap, the Best Thing for Putting in the Heads at Time of Packing.

BOX PACKING OF APPLES.

The bulk of apples handled in the market still comes in barrels, but the first-class apples that bring the fancy prices are handled in boxes. The trade in fancy apples is increasing annually. The barrel is too rough a package for a first-class fruit and is much too large. Many people who would not think of purchasing so large a package as a barrel of apples would gladly buy a box of them. One good box of apples is but the first of a long line that will follow. Last year our apples at the Experiment Station were very conveniently marketed in 40-pound boxes and sold for $1.25 a piece. Hood River Apples is a brand that is found in the market wherever high-quality apples are called for. This brand is not yet a decade old, but its demand in the market has been phenomenal. This year I saw two-layer cases containing 40 apples selling for $1.50, nearly 4 cents per fruit. This almost rivals the price of oranges.

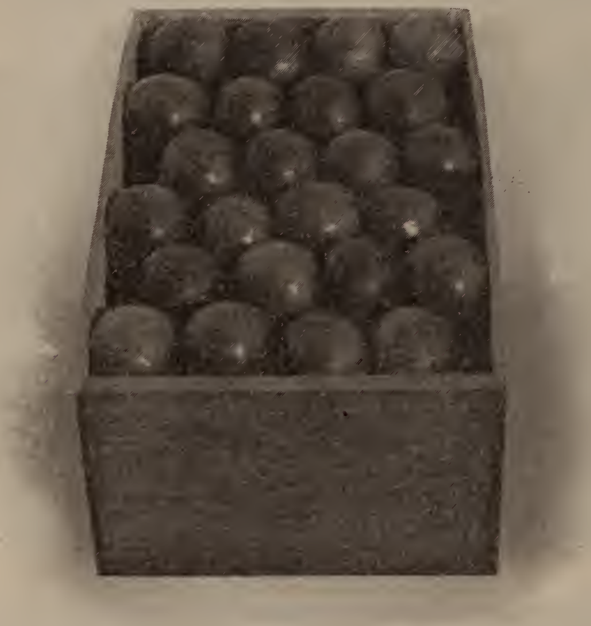


Fig. 13—A Good Pack of Apples.

A Western Maryland grower is putting apples up in boxes and finds that the cost of 3 boxes and one barrel are about the same, and by wrapping the apples in paper he finds that one barrel will fill four boxes. These apples sold for the same price per box as could be gotten for a barrel, thus giving a fine profit for the small extra expense.

The specifications for these boxes were obtained from the Division of Pomology of the United States Department of Agriculture and are as follows: White pine heads 11¾-in.x9-inx⅝-in. dressed on

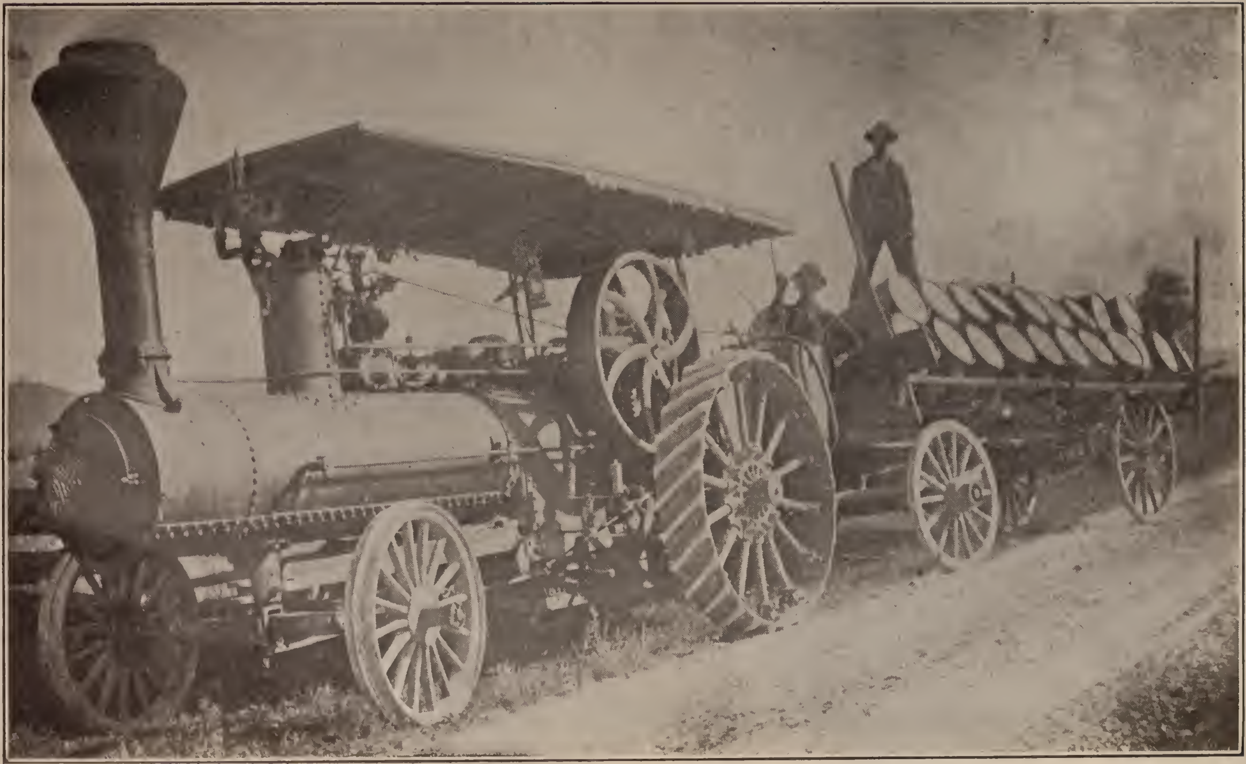


Fig. 15—Hauling Apples to Market in Western Maryland.

both sides. Sides one piece 19¾-in.x9-in.x¼-in. smooth sawed and dressed on one side. Top and bottom each in two pieces 19¾-in.x 5¾in.x¼-in. smooth sawed and dressed on one side. The cleats for putting on top, 11¾-in.x¾-in.x⅜in. For express shipments where the boxes would not be cleated in as they are in car lots, I would advise using ¾-in. instead of ⅝-in. for heads and ⅜-in. instead of ¼-in. stuff for sides, bottoms and tops.

Figure 13 shows a box of select apples properly graded and packed. Each fruit is perfect and is packed in layers so that every fruit fits into its place. Being a much smaller package than a barrel the box does not need much pressing especially since every fruit is fitted in place by hand. When the box is filled the apples of the top layer should stand slightly above the edge of the box. One end of the cover is nailed and the other pressed down and sprung in slightly for nailing. This gives a slight bilge to the box, which holds the fruit firm. Cleats are nailed on each end of the top to make the cover secure and to facilitate the passage of air when the box is stored in car or on shipboard. For long distance shipping the boxes should be cleated in firmly to avoid shifting and bruising of the fruit.

Figure 15 shows a load of 50 barrels of Western Maryland apples being hauled to shipping depot by traction engine.

SHIPPING PEARS.

Pears, especially winter varieties, used to be quite largely shipped in barrels like apples. One sometimes sees them in market today in barrels. Pears of fine quality like Bartlett are shipped in boxes or in ⅝-bu. Delaware baskets. Unfortunately of late years, owing to the ravages of blight, pear growing has greatly decreased and many of the finest varieties have disappeared from the market. Kieffers are able to take care of themselves in almost every package, but bring best returns when neatly put up in box form.

PACKING AND SHIPPING PEACHES.

Peaches were formerly shipped in what was generally known as the Delaware basket. Now the best peaches go to market in the six-basket carriers. See Figure 16. This is a neat slat carrier, somewhat like a berry crate containing six veneer baskets, holding about a half-peck each. Figure 17 shows one of the six baskets packed with peaches. This package carries the tenderest peaches to market in good condition and as they look well on arrival they usually sell for the top price. This package is to be recommended for shipping all first-class fruit. It is too expensive a package to be used for any but the first grade of fruit. Probably no better fruit package for fine fruit has ever been introduced than the six-basket carrier. It can be used for plums or grapes or any high-class fruit and always carries it in good condition and shows it off to best advantage in market. Figure 18 shows one of the trays of the carrier used effectively for marketing

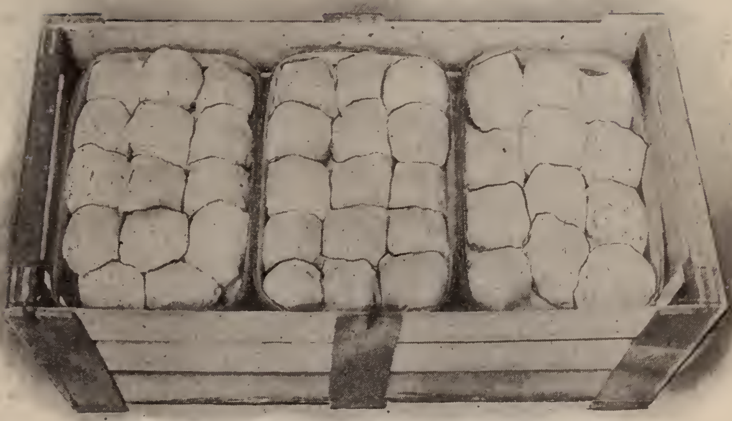


Fig. 16—A Six-Basket Carrier of Peaches.

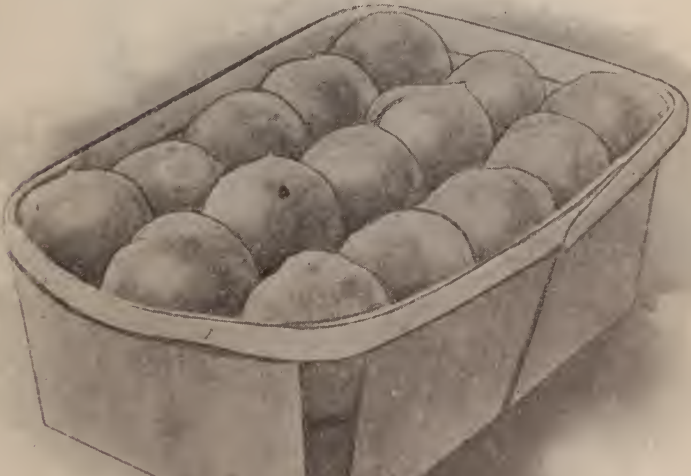


Fig. 17—A Basket Packed With Peaches.

Seckel pears. It is no uncommon sight in our large markets to see fine peaches in these cases selling as high as $3.50 per case. Any one will admit that that is a pretty good price for three-quarters of a bushel of peaches. The dignity of this fine package should be maintained and it should never be degraded by carrying anything but No. 1 fruit.

All general-crop stuff is best handled in the round peach basket. The large bushel basket is not a suitable package for fine fruit like peaches. It does not permit of good packing and the large bulk crushes the tender fruit and renders it unsightly.

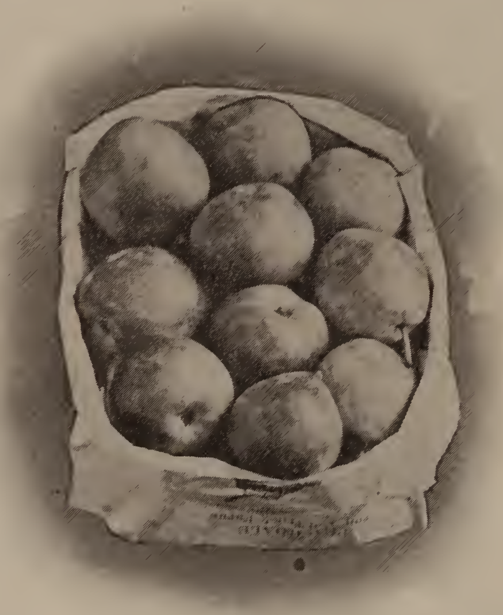


Fig. 18—Seckell Pears, with Veneer Basket.

The grader pictured in Figure 1 is a great labor-saver in grading peaches. It separates the fruit perfectly as regards size into three grades. The sorting table, pictured in Figure 19, is of great assistance in packing peaches. It is separated into shallow compartments that will hold about two bushels of fruit. The side at which the packer stands has a narrow shelf on which the veneer trays are placed while being filled. In the bottom of the compartment is a canvas, which is tacked to the upper edge opposite the sorter. This keeps the fruit from bruising and facilitates the worker's movements in drawing the fruit towards the trays. In the veneer trays or baskets each fruit is fitted into place. Unless the grade is extra large it holds two layers. The table, as will be seen, is constructed in sections which alternate so that fruit may be dumped on the table from either side and the trays carried off handily when filled.

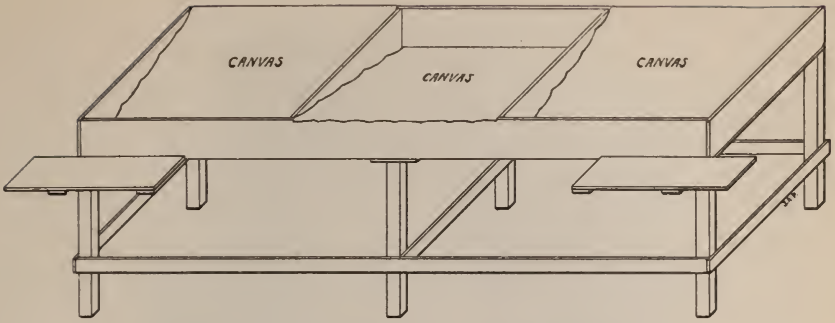


Fig. 19—A Sorting Table for Packing Peaches.

Figure 20 shows a handy picking basket for peaches. As will be seen it is made from an ordinary Delaware basket. The strap goes over the shoulder of the picker and leaves both hands free for gathering the fruit. When filled the basket is easily dumped by unhooking the snap.

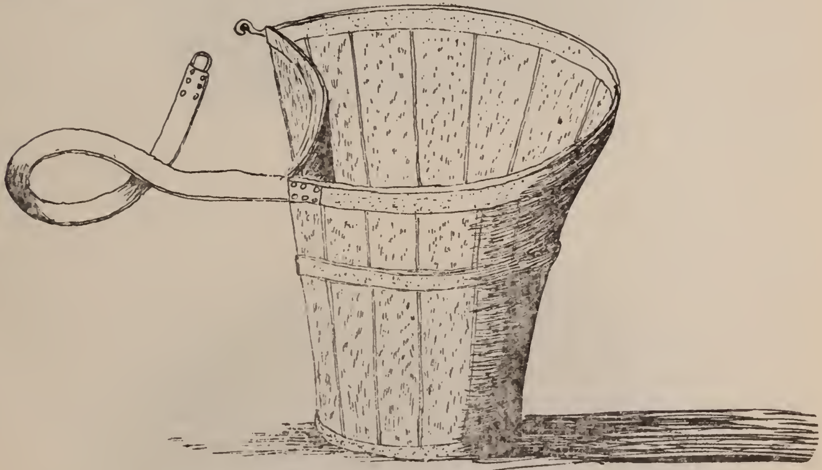


Fig. 20—A Handy Picking Basket for Peaches.

MARKETING PLUMS.

This being a special peach State, plums are not grown in very great quantities. Native American plums are often found on sale locally, but are seldom seen in large city markets. With the advent of the Japanese plums and their hybrids, which seem to be much at home here, plum growing has been on the increase. As small baskets are required by present markets, one often sees Japanese plums for sale in crates like strawberries. Some growers in this state have marketed plums very successfully in this way, a package of which is shown in Figure 21.

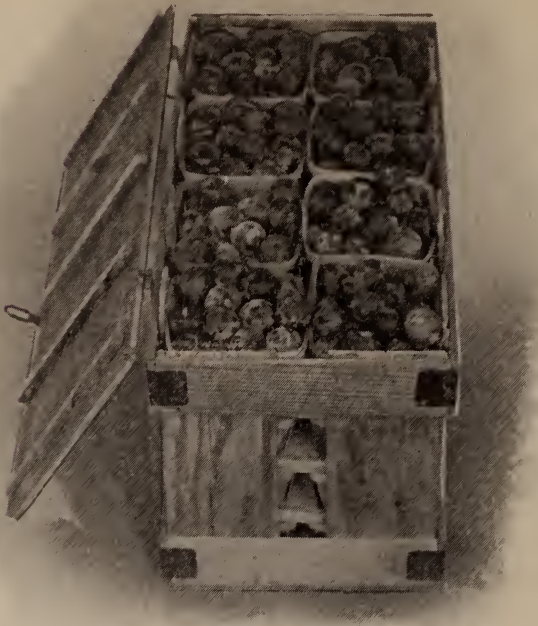


Fig. 21—A Crate of Plums.

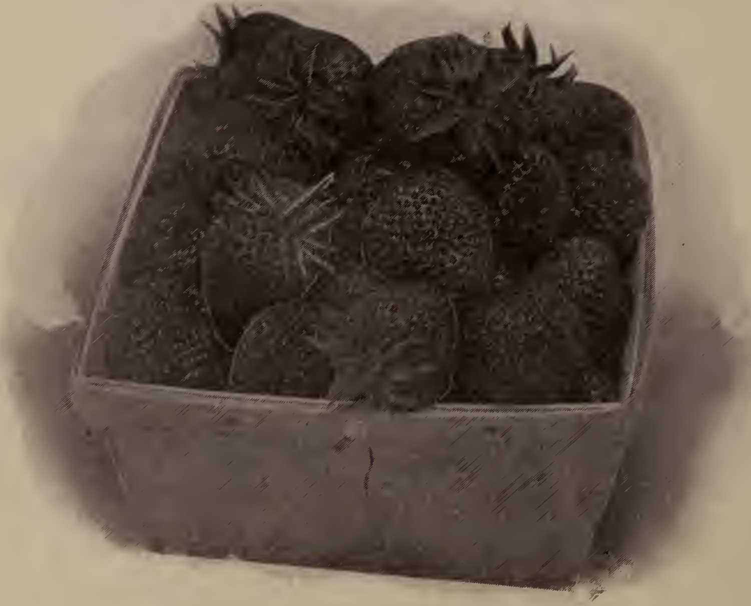


Fig. 22—The Kind of Strawberries That Sell.

MARKETING BERRIES.

Berries are of course picked in the veneer quart basket, but there has been considerable variation in time past as to the size of crates used. Before the advent of the gift package it was the practice of express companies to return crates free. Large crates were then used that would hold 48 to 60 quarts. Now the market wants only 24 and 32 quart basket carriers and whenever a large crate is used it seldom brings first-class returns to the shipper. Besides not carrying the berries well, the large crate holds too great a quantity of perishable fruit for a retail grocer to handle at one time, while in the season he might handle many of the 24-quart carriers. It need hardly be said that all fruit packages sent to market should be clean and neat, yet one often sees, in our large markets, good fruit begging for a purchaser because it is packed in baskets covered with dust, hayseeds and cobwebs. These may appear to be trifling things, but with goods sold almost entirely on their appearance they mean all the difference between success and failure. If baskets or packages are carried over from one year to the next they should be stored away that they may come out in a fresh, clean condition. It does not pay to grade strawberries except in picking them. It is fruit like that in Figure 22 that brings the best prices. It is important that the grower use varieties that will produce maximum crops of large, firm, well-colored berries. Pickers should be instructed not to pick small defective or over-ripe fruits. These always give less trouble when left on the vines.

One of the greatest drawbacks to successful marketing of strawberries is the failure of some growers to mulch their plants. In southern regions mulching may not be considered necessary to protect the plant from cold, but it is always advisable to mulch to keep the fruit clean. Sandy, gritty berries are an abomination to the eater and usually a drug on the hands of the seller. I was told by some wholesale commission men that they would never allow their buyers to go into strawberry regions where growers did not make a practice of mulching their beds.

PACKING AND MARKETING GRAPES.

Grapes are not as often seen in the local markets of this state as they should be. Very small quantities are grown and shipped, and what are used locally come almost entirely from the north. Grape growing in Maryland has decreased largely on account of the rotting of the fruit just before picking time. This trouble, however, is preventable, and our soil and climate are capable of producing large crops of fine grapes. Owing to careful spraying at this Experiment Station we had not over 5% of rot this year (1906) in our whole vineyard of many varieties. It is well known, too, that the growing season of 1906 was very hot and wet; just the conditions most favorable for the development of rots and all kinds of fungous diseases. In spite of these most unfavorable conditions we were able to mature a fine crop of grapes. Some early varieties are not much subject to rot and are especially adapted for growing in this State as they would supply the market before the northern grapes were ripe.

Experience has shown that grapes are most profitably marketed in small, rather than in large baskets. The 3-lb. basket pictured in Figure 23, was bought on the open market for 30 cts., 10 cts. per lb. A price of this kind ought certainly to encourage more extensive vineyard work.

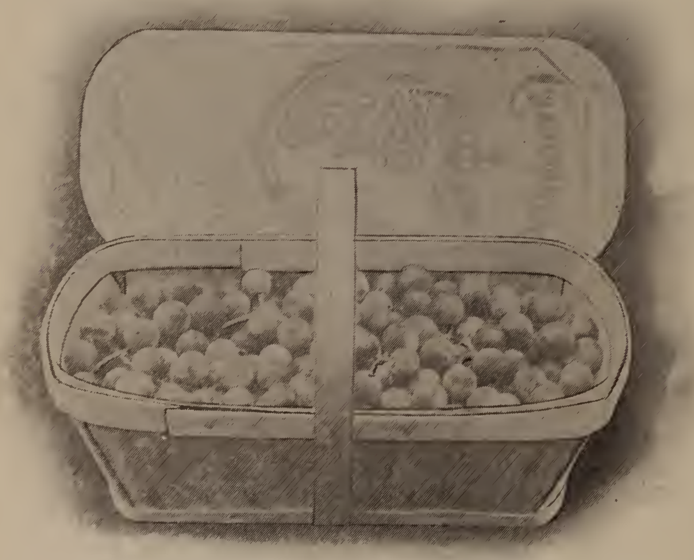


Fig. 23—A 3-lb. Basket of Grapes, Bought on the Open Market.

MARKETING TRUCK CROPS.

Truck growing is a modern horticultural outgrowth due to improved facilities for rapid transportation. Before the advent of extensive steam navigation and the present great extension of railroads each city and town depended for its supply of vegetables on its immediate surrounding country. Today the most distant states in the the Union are sending truck by boat and train load to the great northern centres of population.

WHITE OR IRISH POTATOES.

Bulk or winter potatoes usually go to market in barrels, topped off with a burlap cover as in Figure 24. There is always a regular trade in this staple article of consumption. Grading is as necessary with potatoes as with apples. The little potatoes though they fill up the chinks and corners detract very much from the appearance of the product and should always be left at home. Figure 25 shows an even grade taken from a well-packed barrel. Figure 26 shows the irregular tubers we too often find. Good potatoes should be smooth, free from knobs or second growths and should have shallow eyes. Varieties should not be mixed in the same barrel or package. It hurts their sale to have long potatoes mixed with round ones.

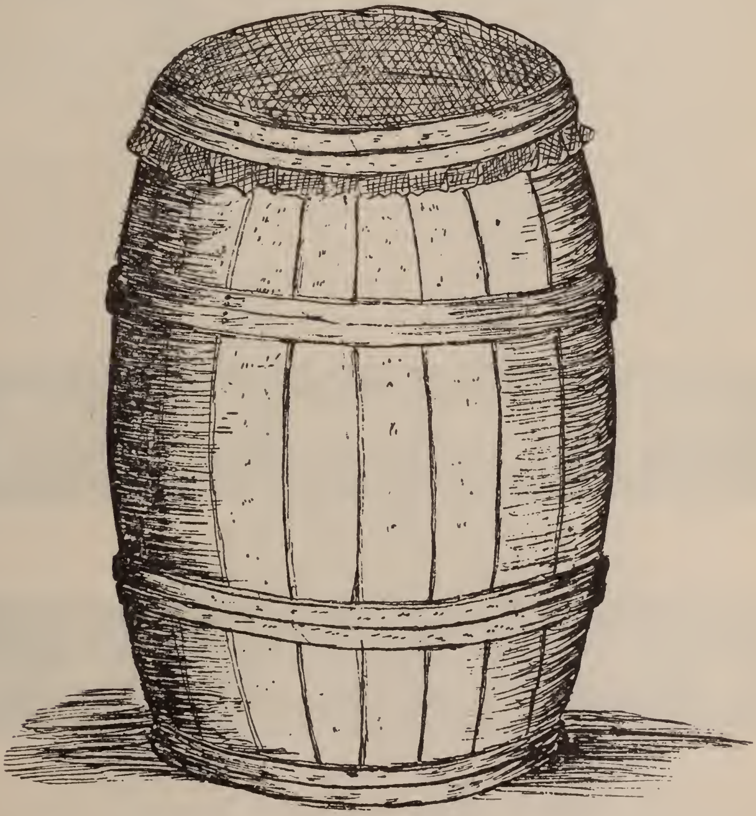


Fig. 24—A Barrel of Winter Potatoes.

The earliest new potatoes in the market are always sure of a ready sale at tip-top prices. There is nothing that gives the trucker more pride, and profit, too, than to beat his neighbor into the market with early potatoes. At that time potatoes are potatoes and do not retail by the barrel, but by the peck and half-peck. Such potatoes have to be handled carefully and are usually shipped in the 1-3 barrel veneer basket. See Figure 27. Care should be taken not to break the tender skin more than possible so as to avoid the ragged appearance seen in some new potatoes when exposed in the market.

Figure 28 shows a good basket of early potatoes.

PACKING AND MARKETING SWEET POTATOES.

Though coming out of the soil there are few vegetables or even fruits that are more perishable than are sweet potatoes. They require the most careful handling and treatment to arrive in market in good salable condition. In the first place, being a southern plant, the sweet potato is very susceptible to frost or cold weather. For this reason "sweets" should be dug before the vines become frozen The first light frost that just tips the outer leaves is a good sign that the time for sweet potato harvesting has arrived. Many people claim that the freezing of the vines injures the quality of the potato and also causes them to rot. A very easy method of harvesting is to plow out the rows using a revolving coulter to cut the vines.

The potatoes may be sorted as they are picked up or hauled in bulk to cellars where they may be graded later when they are cured and the market is right. Whatever method of harvesting is used care should be taken to handle the potatoes as little as possible so as to avoid unnecessary bruising. They should never be thrown into wagons, but picked into baskets and these dumped by a careful sliding movement so as not to scar or bruise the potatoes. Use padded baskets to avoid abrasion. A potato that is cut, broken or bruised when it is dug almost invariably rots unless used for immediate consumption. Potatoes wanted for storage should be kiln-dried. This is usually done by placing them, in not too large quantities, in cellars provided with slatted bins. Pipes, flues or a small stove may be used to dry off the roots. For the first few days the temperature should be carefully kept at about 90 degrees Fahr., ventilating when necessary. During a period of two weeks the temperature is gradually lowered to 60 degrees Fahr. when the fires may be extinguished. This treatment is found to produce a sort of ripening process in the potatoes and after this they show very little injury from handling. In the South sweet potatoes are successfully stored by being piled in conical heaps and covered with corn stalks or pine straw. When cold weather

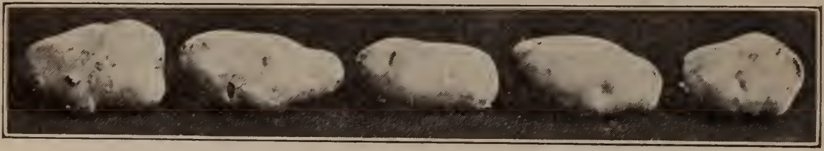


Fig. 25—Uniform Potatoes Desirable for Shipment.

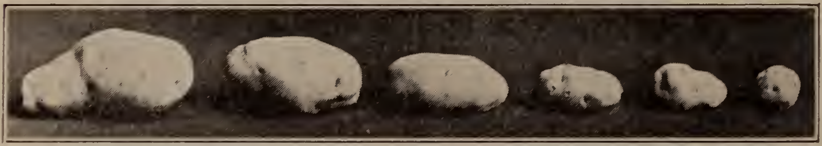


Fig. 26—A Mixed Lot of Potatoes Undesirable for Market.

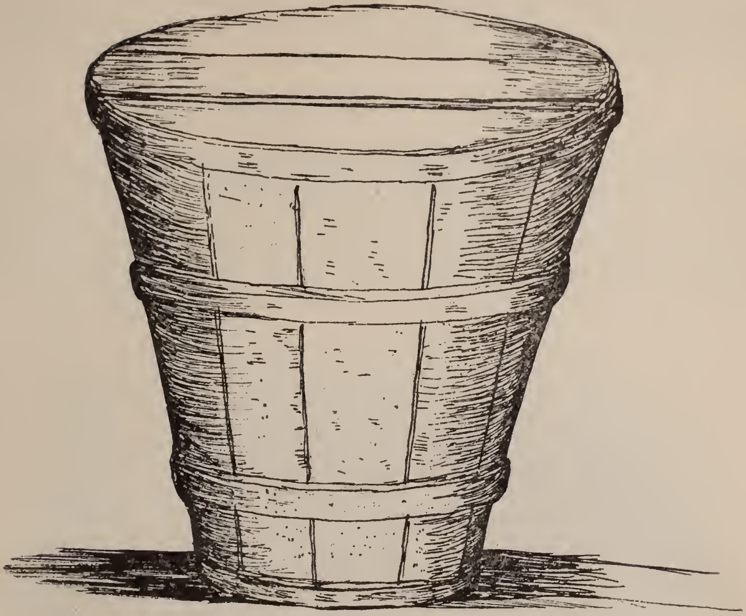


Fig. 27—The 1-3 Barrel Veneer Basket for Sweet Potatoes.

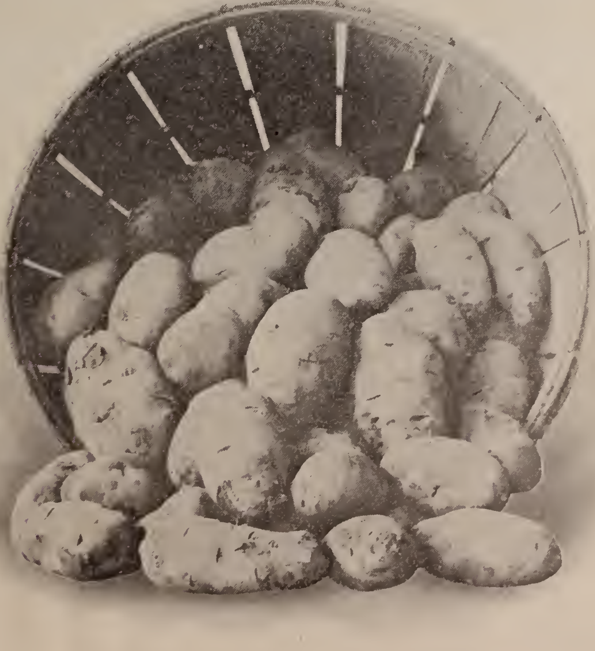


Fig. 28—A Good Basket of Early Potatoes.

approaches a cover of a few inches of earth is thrown upon the stalks or straw. If undisturbed, this covering will usually keep the potatoes till well on into spring.

GRADING SWEET POTATOES.

Sweet Potatoes for the best markets should always be graded. All over-sized roots, the thin ones, the rough, misshapen ones and the "elbows" should be used for stock food or sent to starch factories. What the market wants is a smooth root of a clear orange color and of about 2 to 2½ inches in diameter and roundish rather than long. Figure 29 shows a good sample of marketable sweet potatoes. The usual shipping package for sweet potatoes is the burlap-covered barrel that is used for Irish potatoes. See Figure 24. The 1-3 barrel veneer basket, see Figure 27, is a neater and better package for first-class, well-graded "sweets" and usually brings fancy prices. The most careful shippers of sweet potatoes are now using paper liners for the baskets. The liners keep the potatoes clean and free from dust and protect from any sudden drop in temperature during shipment. These liners are made and sold quite cheaply by many paper manufacturing companies. The liner is made and cut so as to neatly

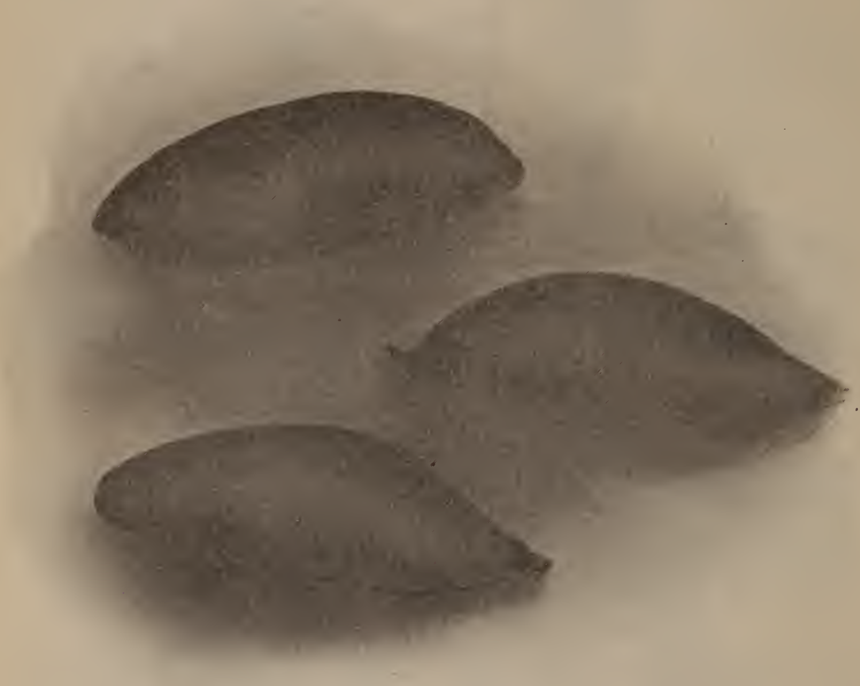


Fig. 29—A Desirable Type of Sweet Potatoes for Market.

fit the sides of the hamper and has a circular top that fits in snugly under the wooden cover. When opened this makes, with good stock, a very salable product.

LETTUCE.

Lettuce is one of the most profitable truck crops. There seems to be an almost unlimited demand in winter for good, fresh head lettuce. The loose sorts do not seem to be wanted in most markets. The best shipping carrier for lettuce is the veneer basket. As lettuce is light in weight compared with most truck the ½-barrel size of basket seems to be most in favor. Figure 30 shows a well-packed basket of head lettuce with cover removed.

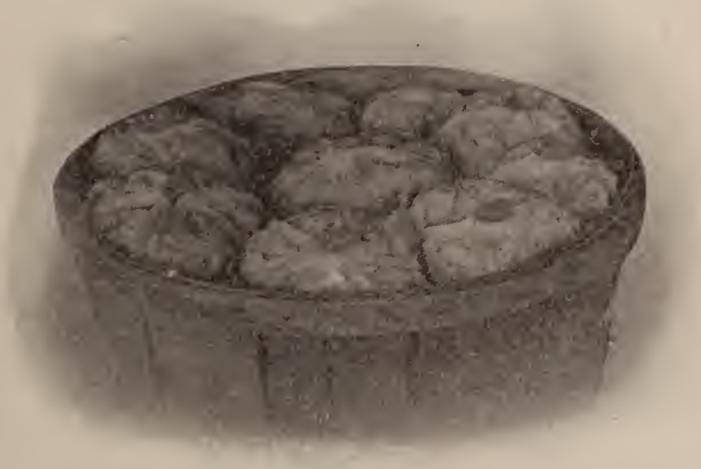


Fig. 30—A Basket of Head Lettuce, Properly Packed.

CUCUMBERS.

Cucumbers being heavier than lettuce are shipped in 1-3 barrel veneer baskets. Figure 31 shows a basket ready for heading up. The cucumbers, as will be seen, are not placed in the basket indiscriminately but are arranged by hand so as to fit closely and to leave a flat surface on top for the placing of the cover. Of course here, as elsewhere, grading is necessary and the more uniform the package the better the sale.

LIMAS, SNAP BEANS AND PEAS.

Limas, snap beans and peas are best handled in the veneer basket, 1-3 barrel size. Figure 32 shows such a basket of limas opened. As this sort of truck loses moisture rapidly in shipping, the basket

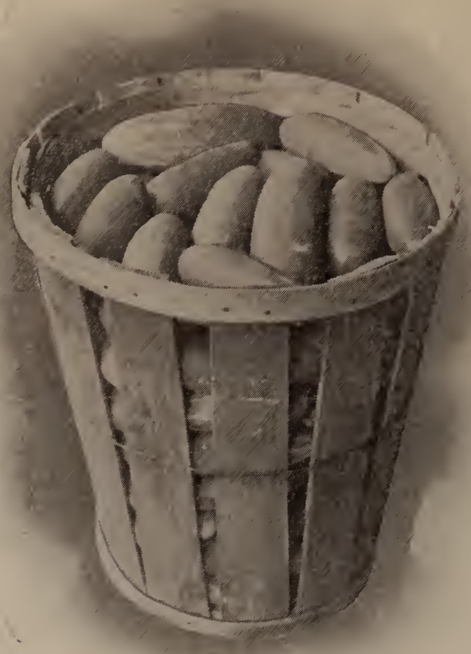


Fig. 31—A Basket of Cucumbers Ready for Heading Up.

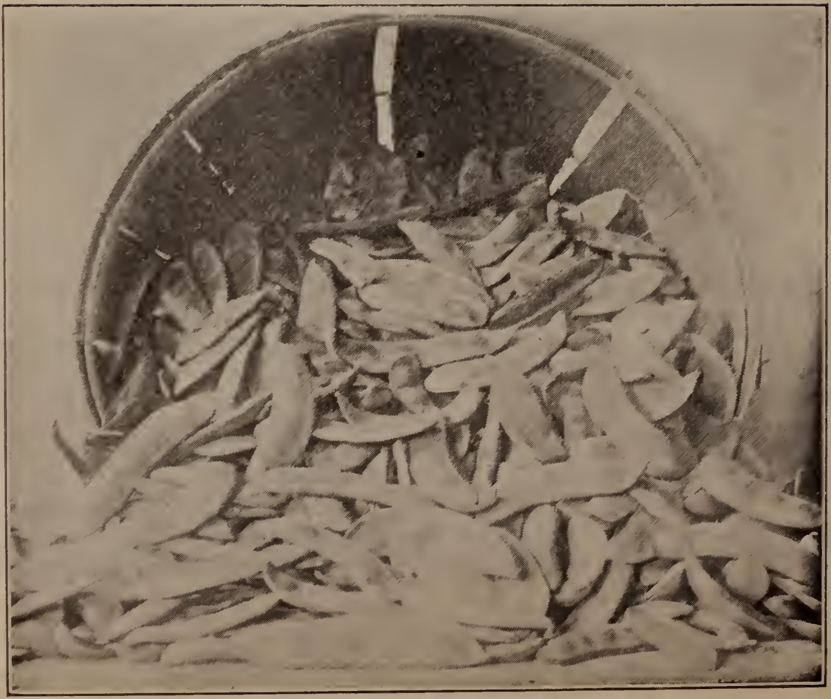


Fig. 32—Limas for Market.

should be well packed and filled before the covers are placed on. There is always more or less shrinkage and if a basket is not full on being opened it does not find ready sale. Truck of this kind should be placed on sale as soon as possible after leaving the field.

PACKING AND MARKETING CANTALOUPES.

Scarcely any branch of horticultural work has increased of late years like the growing of cantaloupes. All markets handle them and are glad to extend their season by getting early and late supplies from all sections of the country. Many varieties of melons and cantaloupes were formerly seen in our markets but present requirements have banished almost all but the Netted Gem or as it is popularly known today, the Rocky Ford. This cantaloupe besides possessing the finest texture and highest flavor is almost round and is thus easily packed. Recent seed selection in this strain has produced a very fine fruit, heavily netted, regular in form and weighing about 1 lb. each. They are put up in crates as in Figure 33, holding 3x3x5—45 fruits. In packing cantaloupes they should be graded as to size. The fruits are placed in the case so that the ribs of the fruit all run lengthwise of the package. This may seem a trifling thing, but it gives the package a special appearance and helps to hold its unique position on the market. None but the heavily netted fruits should be marketed. Figure 34 shows a cantaloupe packing-shed in the height of the shipping season. The fruit is gathered in the field in bushel baskets and hauled to the shed and dumped into the sorting tables. The table is divided into burlapped sections somewhat on the principle of the peach sorting table in Figure 19.

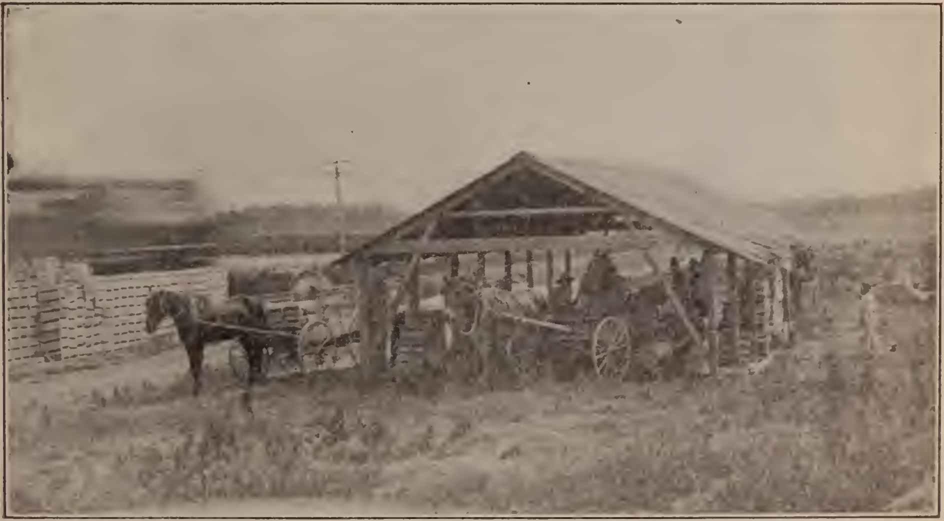
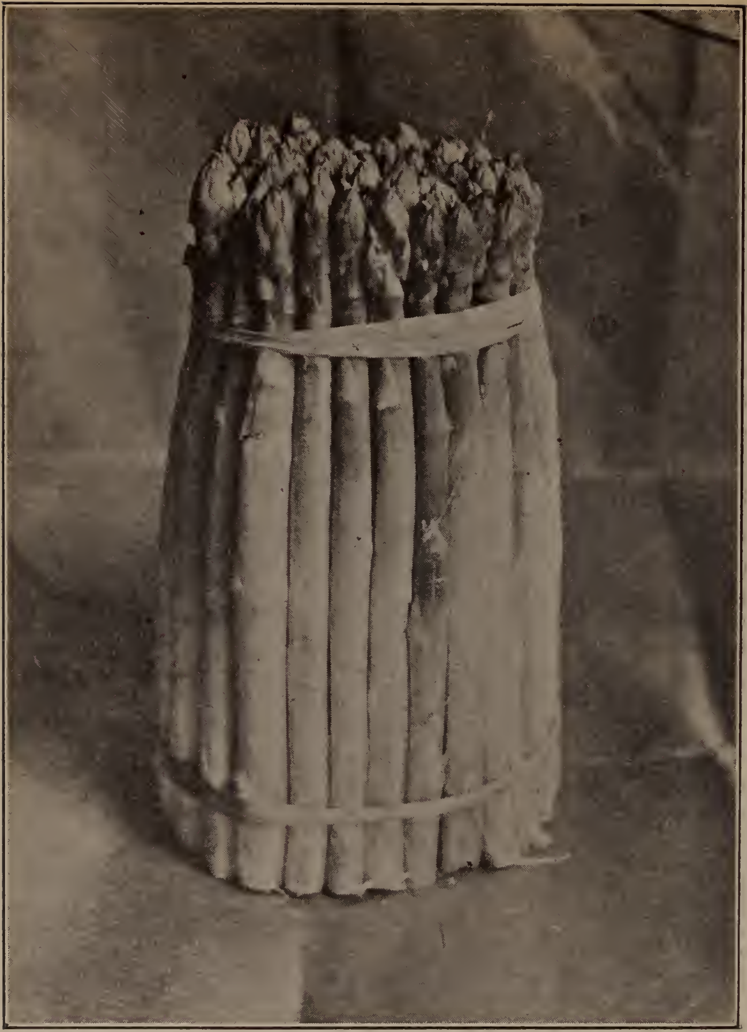


Fig. 34—A Cantaloupe Packing Shed.



Asparagus Bunched for Market.

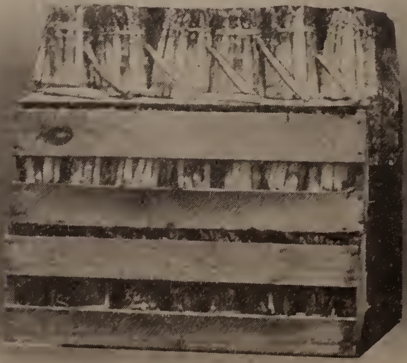


Fig. 35—Asparagus Packed for Shipment, with Specimen Bunches on Top.

MONTREAL MUSKMELON.

Another fancy fruit product is found in the famous Montreal muskmelon. These melons of the Hackensack type are found in some of our large northern markets and often sell for fabulous prices. They are packed with dried grass into large wicker baskets. Each fruit is perfect of its kind and each has on the blossom end a red gum label. On seeing these melons in the market for the first time I priced them and the salesman replied $1.25. I remarked that it seemed rather cheap for the whole case. The merchant stared at me as if I were crazy and said $1.25 per melon, the whole case is worth $10.00. Instances might be multiplied of a wonderful trade built up on fancy brands of fruit.

ASPARAGUS.

Asparagus where it can be grown free from rust is one of the best paying of truck crops. It occupies the season between frost and green peas. In isolated locations where the asparagus beetle is yet unknown the green asparagus can be raised. This is more tender and of better quality than the white asparagus, which is bleached by banking and cutting the stalks just as the points appear at the surface. The white or bleached asparagus is firmer and looks somewhat better than the tender green stalks. The stalks are usually cut in the field and bunched in an open packing shed. The bunches are made by hand and weigh about two pounds. Fairly long stalks are preferred, but if they are a little short, are made into thicker bunches. Bunches are usually tied twice with string or raffia. Some growers use elastic bands. There are patent bunchers made for holding the stalks for tying and cutting to the proper length. Small home-made stands can be constructed, which assist considerably in the bunching operation. Figure 35 shows two cases of asparagus packed for shipping. On top will be seen several uniform bunches.

CABBAGE.

A considerable portion of the cabbage crop is handled in bulk. When forwarded by car-load or ship-load the heads are cut from the stalks with a heavy knife or light hatchet and all the outer leaves left on. When prepared for market they are dressed up by removing the outer unbleached leaves. Cabbages are often shipped in ventilated or slat barrels. Tight barrels keep them too warm and may cause rotting. By far the best carrier for shipping cabbage is the barrel-size crate. This carries the heads securely, packs in well on board train or boat, and shows the quality of the stuff when arriving in market. The heads should be packed in the crates carefully by hand so that the carriers will not be slack when received by the wholesalers. Figure 36 shows a cabbage-packing scene. The crates in the foreground have been used in collecting the heads in the field. Those on end in the background show the cabbages ready for shipping.

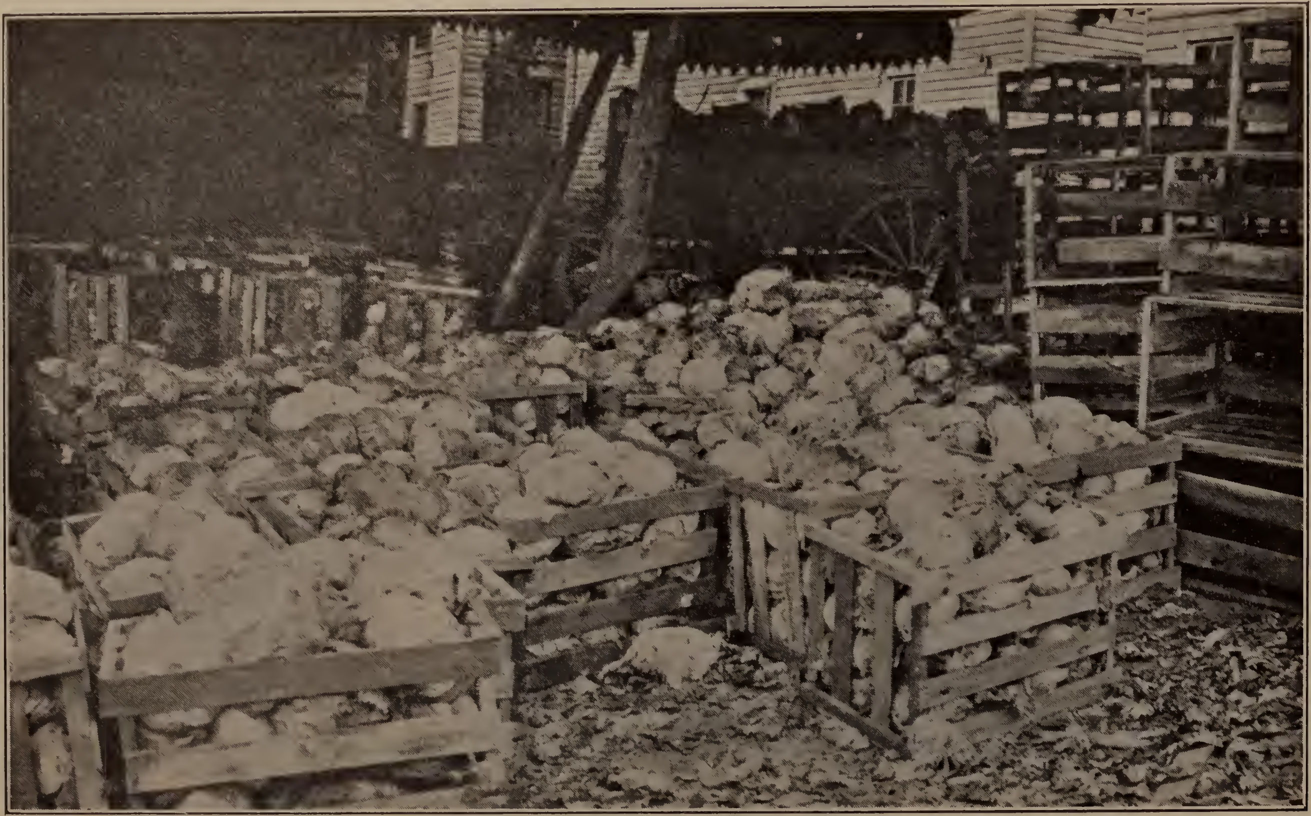


Fig. 36—Packing Cabbage for Market.

CELERY.

Celery, when fully grown and bleached, is prepared for market by trimming off the roots so as to leave the short solid stem. The tops are never cut, but any loose outside stems and leaves may be removed. The stalks when thus dressed are made into bundles of one dozen each, and tied twice with light tape to hold the stalks together in position. These bundles are packed into an open crate, which is 22x24 inches and 20 inches high. The crate is packed full, placing the stalks in upright position. The crate will hold ten or a dozen bunches of ordinary size. Larger or smaller crates of this kind can be used to accommodate varieties with larger or smaller stalks. The crate has no cover and the leaves project over the top if the stalks are of extra length. Sometimes celery is shipped in crates where the bunches are laid flat and the tops lapped, but it often causes the leaves to decay and gives the stalks an unsightly appearance. The open crate described above is, by far, the best carrier for celery.

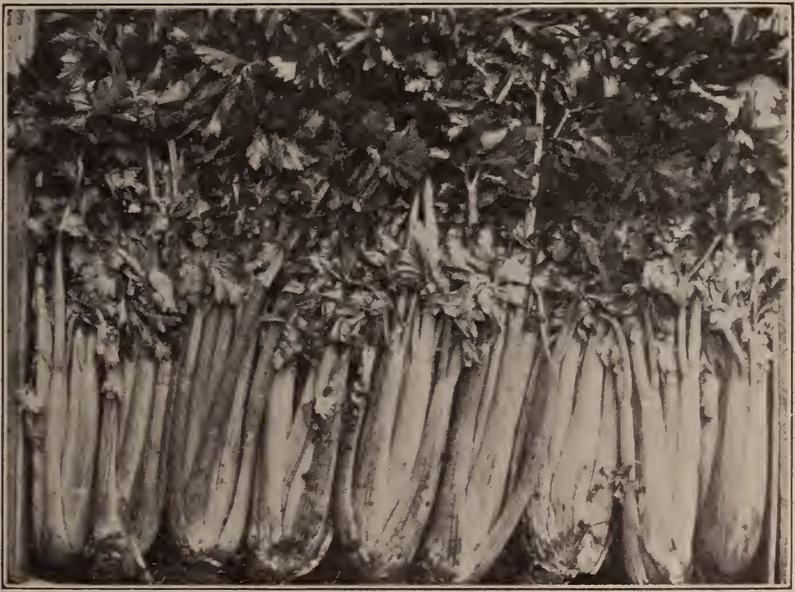


Fig. 37—Celery Packed for Market.

Figure 37 shows a crate of celery packed for shipment.

EGGPLANT.

The fruit of the eggplant is a fine vegetable that is rapidly becoming more appreciated and better known on our markets. The fruits, though large, are rather tender and should be carefully handled to preserve their smooth shining surface and deep purple color. They are best handled in the 1-3 barrel veneer basket; the same size used for cucumbers and early potatoes. Cauliflower can be packed and handled in the same size basket as the eggplant. Figure 38 shows a basket of eggplant as opened in market.

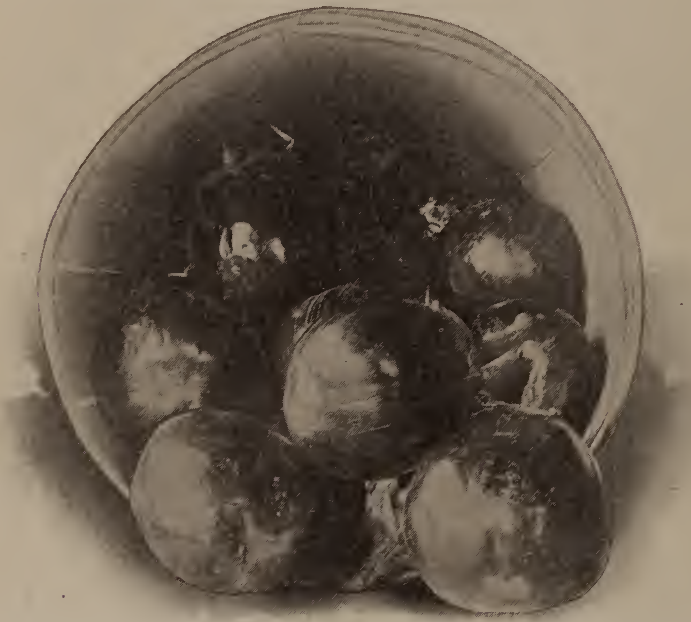


Fig. 38—A Basket of Eggplants as Opened in Market.

HUCKSTERING.

There are few cities of any size with agricultural surroundings where there is not a considerable huckster trade in home-grown fruit and vegetables. Other things being equal there is usually a preference for vegetables and fruits that still have upon them the dewy freshness of a country morning. The charm of early vegetables is their crispness. This is often lost in imported truck unless handled by express or refrigerator shipments. The home-grower who raises his vegetables and brings them fresh to the door is like the early bird in the proverb. But the freshest of vegetables soon shows the effect of a summer sun and crisp lettuce and fresh peas soon give evidence of an unattractive and unsalable appearance. Vegetables should therefore be exposed to drying as little as possible. A canvas cover for the whole load is a great protection on the way to market, but in the city it hides the attractive wares and impedes selling. Figure 39 shows a huckster's wagon designed to keep vegetables fresh and salable. The glass-panelled sides and ends advertise the contents and show the whole load off to great advantage.

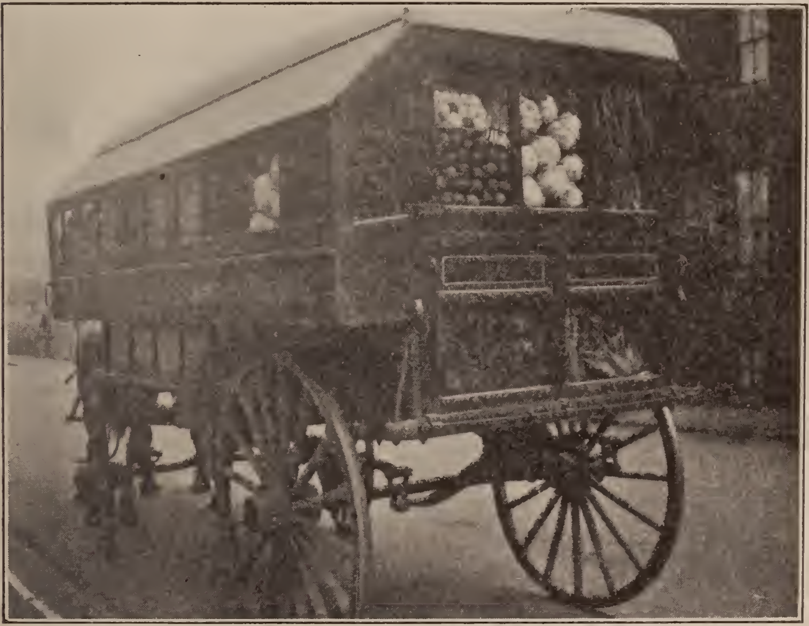


Fig. 39—A Good Huckster's Wagon.

THE MARYLAND
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THE DIGESTIBILITY OF MOLASSES FEEDS.

By H. J. Patterson and Raymond Outwater.

PREFACE.

The experiments reported upon in this bulletin were planned by and carried out under the direction of H. J. Patterson and the details of the feeding were supervised by and the sampling and chemical work performed by Mr. Outwater. At the time of Mr. Outwater's death on February 9, 1907, he was in the midst of preparing the tables for publication. The final calculation of the results and arrangement of the tables and the discussion and preparation of the bulletin was done by H. J. Patterson.

The increase in the production of sugar in the United States in recent years has caused the utilization of the Molasses by-product to become an important factor.

At one time most of the molasses produced in the United States was sold for table use; but now this trade takes but a small percentage of the product. The demand for molasses has also relatively decreased owing to the poorer quality of the product as a result of the improved methods for sugar extraction.

During the past few years large quantities of molasses has been used for fuel at the place of manufacture and a considerable amount has been thrown away as there was no demand for it for any purpose whatever. Large quantities of certain grades of molasses have also been used for the manufacture of alcohol and this use will now probably increase with the more liberal provisions allowed by the recent denaturized alcohol legislation.

Molasses Stock feeds have been used extensively in Germany and other European Countries for many years. During the past few years the question of the use of molasses as a stock food has been agitated considerably in this country and resulted in the placing of a number of molasses feeds upon the market and the consumption of large quantities in this way.

The scarcity and high price of all cattle foods has brought to the Experiment Station numerous inquiries as to the value of every new feed on the market and particularly of the many molasses feeds. In order to have more definite data than was available on this subject it was decided to make a special study of the food value and digestibility of molasses and molasses feeds. In this piece of work the effects of molasses on digestibility and the digestibility of the molasses feeds most commonly found in this market was determined. The work as originally planned included several more than reported upon but the tests with these could not be carried out as there was no feed available on the market at the time they were wanted for the experiment.

HISTORY OF THE USE OF MOLASSES FEEDS.

The first suggestion of the use of molasses as a stock food was made by Hermstadt in 1811. The first recorded ration was used in 1830 and consisted of chopped straw and 220 pounds of molasses per day for 2000 sheep, 80 head cattle and 20 horses. In 1850, rations mentioned by Stockhardt, Henneburg and Stohman, consisted of Molasses Oat-straw and Hay. They limited the amount of molasses to 8 pounds per 1000 pounds, live weight of the animal fed. By 1860 the use of molasses became quite general in Germany, France and Russia, and by 1870 its use had spread to England. Owing to the cost of molasses and the variability of the product, the demand for it did not increase rapidly until about 1890 when the increased production caused a marked decrease in price. It is estimated that now about one-third of the molasses produced in Europe is used as forage for stock.

It is fed directly to cattle but usually diluted and absorbed on cut straw, hay and cereal waste or peat. In Louisiana and Texas when feeding molasses about 5 pounds per day is used for cattle, and about 12 pounds for mules This is mixed with the hay and grain or sprinkled on cane tops. The amount of the other feeds required is considerably diminished by the use of molasses.

MOLASSES FEEDS.

Molasses feeds are becoming very popular. They are made of various mixtures of grains, oat offal, refuse from flouring mills, ground corn stalks, finely ground hay, rice hulls, malt sprouts, brewers grains, distillers grains, cotton seed meal and similar products with 10 to 30 per cent of molasses. There are a great many low class of products in these mixtures and many times the molasses is used to conceal poor goods.

In manufacturing molasses feeds the simple mixing of the materials and molasses is not sufficient. Artificial drying must be resorted to. If these feeds are not dried sufficiently fermentation sets in and spoils the feed. This is more likely to happen in warm weather. A molasses feed should not carry over 10 to 12 per cent of molasses.

AMOUNT OF MOLASSES AVAILABLE.

The amount of molasses available for feeding purposes in the United States has increased considerably during recent years. The Census report for 1900 gives the yield from Cane Sugar as 16,505,119 gallons. There is no data recorded for the yield of beet molasses; but this source has increased greatly in the last few years and probably is at least one million gallons. Hawaii produces 4,416,631 gallons of molasses which has had practically no selling value whatever. In addition to the supplies produced in the United States considerable molasses now comes into the markets from Cuba and other nearby islands, and the product may, in fact, be considered available to our people as a source of supply for stock feeding.

MANUFACTURE OF CANE SUGAR AND MOLASSES.

The manufacture of raw sugar from the sugar cane takes place in four steps:

(a) Extraction of the juice—the leaves are stripped from the cane before it is brought in from the field. It is then brought to the mill and crushed to express the juice—an operation which must be done promptly in order to avoid losses by fermentation. The juice is caught in a trough beneath the mill and drawn off. The "begasse" or "trash" is burned under the boilers.

(b) Clarification. In addition to the bits of sugar-cane which are removed by straining, the juice contains organic acids, nitrogeneous bodies and invert sugar, which are easily susceptible to fermentation. These are removed by "defecation." The juice is passed into tanks warmed by steam coils, and treated with milk of lime until the acids are *almost* neutralized. This coagulates the albumin and part of the gummy matter, which is then skimmed off, leaving the filtrate or sugar solution ready for evaporation.

(c) Evaporation. The juice is generally concentrated in vacuum pans, which are usually arranged in series of three, until the solution contains about 50 per cent of solid matter, when it is transferred to a simple vacuum pan called the "strike pan" where the evaporation is slowly continued under high vacuum. The object being to build up crystals on the crystal points.

(d) Separation of the Crystals. When the grain has reached the desired size the mixture of crystals and syrup which is called "masse-cuite" is emptied into storage tanks, where it cools somewhat. It is then run into centrifugal machines, where the molasses is separated from the sugar. The latter is called the "First Sugar" and is at once packed for the market. The molasses thus obtained is called *first molasses* and contains 45 to 50 per cent of sugar which is not crystalizable. It is diluted and defecated with lime, as above, and the clarified syrup reboiled in vacuum pans to obtain a "Second Sugar." This forms very slowly. The mass is then centrifugated yielding a "second or molasses sugar" and "second molasses." This second molasses contains about 40 per cent of sugar which it does not pay to recover, and it is this molasses which is sometimes fermented for making alcohol or rum, and also used as a feed for cattle.

PREPARATION OF RAW SUGAR AND MOLASSES FROM BEETS.

The manufacture of sugar and molasses from beets, may be outlined as follows:

(a) Washing and slicing the beets. The beets are mechanically washed to remove the sand and loam which usually adheres to them and then cut into slices from 0.5 to 1.0 inch thick by a machine containing revolving knives.

(b) Extracting the juice. The juice is usually extracted from the sliced beets by the *diffusion process.* The slices are put into vertical iron cylinders and systematically digested with water at a temperature of 60°C. These digesters are arranged in batteries. The juice is removed and fresh water added until all but 0.5 per cent of the sugar is extracted.

(c) Clarifying. This is done in practically the same manner as in making the sugar cane.

(d) Evaporating. The evaporation is carried out in two stages, by the use of the triple vacuum pans and "strike pan" as in the preparation of cane sugar.

(e) Separating the crystals. The molasses is separated from the sugar by centrifugal machines as described under cane sugar. The sugar thus obtained closely resembles the first sugar from the sugar cane.

(f) Treating the molasses. The molasses is boiled down for a second sugar and second molasses as already described. The latter contains over 40 per cent of sugar which cannot be crystallized. This is now generally recovered by treating the molasses with quick-lime or strontium hydroxide in excess. A tricalcium sucrate $C_{12}H_{12}O_{11}\ 3\,CaO$ is formed which may be washed with alcohol to remove the new sugar substances; or it may be separated from the diluted syrup as a precipitate and filter pressed, leaving the impurities in solution. It is then powdered and mixed with water to form a paste; this is either used instead of lime for defecating the fresh juice or is decomposed by passing CO_2 into it. In either case, the lime precipitates leaving the sucrose in solution.

Beet sugar molasses contains a large amount of potassium salts, especially potassium sulphate, which prevent the crystallization of a part of the sugar content. These may be removed by adding aluminum sulphate, this forming alum with the potash salt. This may be separated by dialysis, the potash salts passing through the membrane and the sugar remaining. But sugar molasses also contains certain nitrogenous bodies (amides) which impart a very unpleasant odor and taste, rendering it unfit for table use. But it is nearly free from an invert sugar and glucose, for which reason large amounts of lime may be used in defecating, without injury to the sugar.

TABLE I.

Composition of various grades of Sugar Cane Molasses.
Yield, starting with 1,000,000 lbs. cane.*

	Lbs.	Total Solids	Sucrose	Dextrose	Levulose	Ash	Albuminoids	Amides, etc.	Acids, germs, etc.	
1st Molasses	64,500	80.00	44.80	11.40	10.80	4.50	.22	1.78	6.50	Poor Juice
2nd "	41,000	80.00	31.40	15.00	16.00	5.60	.30	2.40	9.30	" "
1st "	71,213	80.00	53.60	8.76	8.00	4.00	.20	.94	4.50	Average Juice
2nd "	42,563	80.00	41.70	12.20	12.50	5.35	.25	1.50	6.50	" "
1st "	54,563	80.00	58.90	6.00	5.80	4.70	.25	1.85	2.50	Good Juice
2nd "	24,269	80.00	39.70	11.40	12.00	8.00	.40	3.50	5.00	" "
3rd "	18,284	80.00	29.40	13.60	15.80	9.80	.43	3.97	7.00	" "

*By C. A. Brown, Jr., International Sugar Journal, July 1906, No. 91, Vol. 8, p. 364.

*COMPOSITION OF BEET SUGAR MOLASSES.

Sp. Gr.	Water	Sucrose	Invert Sugar	Nitrogen				Organic Non-sugar	Ash
				Total	Protein	Non-Protein	Nitric Acid		
1.412	22.50	51.45	.19	1.64	.12	1.52	.13	18.73	7.10

*From Konig-Chemie der nunschlichen Nahrungs Und Genuss Mitlel. S. 982-3- II Band.

TABLE II.

Composition of the Ash of Molasses from Different Sources.

	I.	II.	III.	IV.	V.
Potash K_2O	49.48	52.20	51.48	50.16	49.92
Soda Na_2O	0.89	0.80	1.11	0.32	9.24
Lime CaO	6.47	6.78	6.58	8.53	4.92
Magnesia MgO	4.29	3.09	3.99	2.66	0.15
Iron Oxide Fe_2O_3	0.35	0.33	0.15	0.47	0.48
Alumina $A1_2O_3$	0.30	0.22	0.13	0.30	....
Silica SiO_2	4.12	4.59	2.83	4.10	0.06
Phosphoric Acid P_2O_5	3.71	3.80	2.12	0.91	0.43
Sulphuric Acid SO_3	10.79	6.72	10.94	11.18	1.42
Carbonic Acid CO_2	7.49	11.19	13.06	15.78	28.51
Chlorine C1	14.00	11.95	9.10	4.59	7.06
Total	101.89	101.67	101.49	99.00	102.19
Deduction O=C1	3.16	2.70	2.05	1.04	1.60
	98.73	98.97	99.44	97.60	100.59
Undetermined (carbon, etc.)	1.27	1.03	.56	2.04	none
Alkalinity c. c. N/10 per grain ash.	80 c. c.	93 c. c.	95 c. c.	109 c. c.	....

Analyses I, II, III, IV are from a report read at International Congress of Applied Chemistry, held at Rome in 1906, and published by the author, Dr. C. A. Browne, Jr., in the International Sugar Journal, of Altringham, Manchester, England, July, 1906. Vol. 8. No. 91.

I. Mill Sulphitation.
II. Diffusion Sulphitation.
III. Open Kettle.
IV. Carbonatation.

These do not represent single analysis, but averages of many obtained by these different processes in the State of Louisiana.

No. V is an average of three samples by K. Hammer, as published in Cheim der nunschlichen Nahrungs und Genuss mittee von Dr. J. Konig. II. Band. S. 982-3.

PROPERTIES OF MOLASSES.

Molasses whether obtained from the sugar-cane or from beets probably owes its value as a feeding substance primarily to the sugar contained in it. As has been stated, beet sugar molasses contains a large amount of salts, particularly potassium salts—especially potassium sulphate, which prevents the crystallization of the sugar in the molasses. This molasses also contains more nitrogenous matter, amides, which impart an unpleasant odor and taste, and render it unfit for table use, but it is nearly free from invert sugar and glucose.

On the other hand, cane sugar molasses is nearly free from nitrogenous bodies, and hence the unpleasant taste and odor; but contains considerable amount of glucose and invert sugar.

Physiologically, it seems to be pretty generally admitted that in feeding molasses, one of the first results to be noted is that diarrhoea is apt to follow. Although it has been stated that this seems to be only a temporary disarrangement, and need cause no alarm. This will be further discussed in the course of the present work.

PLAN OF THE EXPERIMENTS.

The experiments conducted in the study of sugar feeds consisted in a study of the digestibility of the principal sugar feeds in the market, and the effects of molasses on the digestibility of hay and mixed grain rations. The experiments outlined were to include a study of effects of these feeds upon the quality and quantity of products, but the work on this portion of the investigations has been delayed so as to make it necessary to leave it for a report at some future time.

LIST OF TESTS MADE.

The following are the experiments conducted and reported upon in this bulletin.

I. A study of the effect of molasses on the digestibility of hay.

II. A study of the effect of molasses on the digestibility of a mixed grain ration.

III. A determination of the digestibility of sucrene dairy feed.

IV. A determination of the digestibility of Mueller's Molasses Grains.

V. Effects of molasses on Nitrogen Metabolism.

TIME AND DURATION OF EXPERIMENTS.

Period.	Steer No.	Preliminary Began. 1906.	Digestion Began.	Digestion Ended.	Ration.
I...	Steers 1 and 2.	Apr. 25, P. M.	May 7, A. M.	May 12, A. M.	Hay.
	" 4 and 4.	Apr. 30, P. M.	May 14, A. M.	May 19, A. M.	
II..	" 1 and 2.	May 12, P. M.	May 21, A. M.	May 26, A. M.	Hay and Sucrene.
	" 3 and 4.	May 19, P. M.	May 28, A. M.	June 2, A. M.	
III.	" 1 and 2.	May 26, P. M.	June 4, A. M.	June 9, A. M.	Hay and Grain.
	" 3 and 4.	June 2, P. M.	June 11, A. M.	June 16, A. M.	
IV.	" 1 and 2.	June 9, P. M.	June 18, A. M.	June 23, A. M.	Hay & Grain and Molasses.
	" 3 and 4.	June 16. A. M.	June 25, A. M.	June 30, A. M.	
V...	" 1 and 2.	June 23, P. M.	July 2, A. M..	July 7, A. M.	Hay & Mueller's Molasses Grain.
	" 3 and 4.	June 30, P. M.	July 9, A. M.	July 14, A. M.	
VI..	" 1 and 2.	July 7, P. M.	July 16, A. M	July 21, A. M.	Hay and Molasses.

It will be noted that each period consisted of a preliminary period of nine days and a digestion period of five days.

METHODS AND APPARATUS USED.

In the digestion experiments the dung and urine were collected and samples drawn daily from each, for analysis. The samples of dung were dried in the steam oven to the air dried state. The size of the sample dried out was in proportion to the total amount of excreta. Composit samples were made up from the daily samples for each steer for each period. The nitrogen in the urine was determined daily in fresh samples by the Kjeldahl method.

The animals were kept in the digestion apparatus described in Bulletin 43 (page 167) of the Station. The feeds were analyzed according to the methods of the Official Agricultural Chemists, except that the sugars were determined by Low's method which is as follows:

LOW'S VOLUMETRIC METHOD (MODIFIED).

For the determination of the Copper in the Cuprous Oxide Precipitate.

Standardization of the thiosulphate solution. Prepare a solution of sodium thiosulphate containing 19 grams of pure crystals to 1000c.c. Weigh accurately about 0.2 gram of pure copper foil and place in a flask of 250cc. capacity. Dissolve by warming with 5cc. of a mixture of equal volumes of strong nitric acid and water. Dilute to 50cc., boil to expel the red fumes, and add 5cc. of strong bromine water, and boil until the bromine is thoroughly expelled. Remove from the heat and add a slight excess of strong ammonia (7cc. is about the right amount). Again boil until the excess of ammonia is expelled, as shown by a change of color of the liquid, and a partial precipitation. Now add a slight excess of strong acetic acid (3 or 4cc. of 7 per cent acid) and boil for a minute. Cool to room temperature and add 10cc. of a solution of pure potassium iodide containing 300 grams of potassium to 1000cc. Titrate at once with the thiosulphate solution until the brown tinge has become weak, then add sufficient starch liquor to produce a marked blue coloration. The blue color changes toward the end to a faint lilac. If at this point the thiosulphate be added drop by drop and a little time be allowed for complete reaction after each addition there is no difficulty in determining the end point within a single drop. 1cc. of the thiosulphate will be found to correspond to about 0.005 gram of copper.

Determination of Copper. After washing the precipitated coprous oxide, cover the gooch with a watch glass and dissolve the oxide by means of 5cc. of warm nitric acid (1:1) poured under the watch glass with a pipette. Catch the filtrate in a flask of 250cc. capacity, wash watch glass and gooch free of copper (50cc. of water will be sufficient). Boil to expel the red fumes, add 5cc. of bromine water, boil off the bromine, and proceed exactly as in standardizing the thiosulphate.

ANIMALS USED.

The steers used in these experiments were grade short horns two years old. They were obtained from the Washington Stock Yards, to which place they had been shipped from Frederick County, Md. They were in fair flesh at time of purchase, and would have gone to the butcher had they not been purchased for this experiment. They were not in high flesh and would not have been termed ripe by the feeder.

No. 1 would be classed as a medium feeder.

No. 2 and No. 3 were not of as good a type as No. 1, but would have been termed fair.

No. 4 was an almost ideal type of steer for feeding.

They were quiet steers, easy to handle, had good appetites and at no time showed any discomfort or uneasiness and on the whole proved to be exceedingly well adapted to the work for which they were used.

FEEDS USED.

The feeds used will be discussed more in detail under the different experiments.

The composition of the feeds used and the dungs collected during the disgestion periods are given in the following tables:

TABLE V.

Composition of feeds used in the following experiments.

Anal. No.	Description	Moisture	Dry Substance	Ash	Nitrogen	Crude Protein	Ether Extract	Crude Fiber	N-Free Extract	Sugars Before Inv.	Sugars After Inv.
843	Hay. Period I	10.04	89.96	4.28	1.24	7.72	2.43	32.73	42.80	2.32	3.06
866	Hay. Periods II-V	10.40	89.60	4.25	1.31	8.16	3.36	29.21	44.62	3.00	3.84
908	Hay. Periods II-V	12.08	87.92	4.37	1.22	7.63	5.78	30.28	39.86	0.64	1.18
xxx	Hay (Average)*	11.24	88.76	4.31	1.27	7.94	4.57	29.74	42.20	1.82	2.51
972	Hay. Period VI	12.29	87.71	3.84	1.21	7.55	2.27	31.57	42.48	0.76	1.27
973	Hay refused Steer No. 1, I-V.	11.66	88.34	4.67	0.90	5.62	2.22	33.91	41.92	1.44	2.95
974	Hay refused Steer No. 2, I-V.	10.17	89.93	4.12	0.72	4.48	5.45	33.38	42.40	2.10	3.59
975	Hay refused Steer No. 3, I-V.	11.78	88.22	4.35	1.09	6.77	2.78	35.33	38.99	1.27	2.24
976	Hay refused Steer No. 4, I-V.	15.76	84.24	5.62	0.98	6.11	2.51	34.44	35.56	0.24	2.19
978	Hay refused Steer No. 2, VI.	17.45	82.55	5.00	0.95	5.93	1.07	39.24	31.31	0.60	0.61
844	Sucrene	11.77	88.23	6.95	2.71	16.94	6.88	9.60	47.86	10.86	12.56
845	Wheat Bran	11.46	88.54	5.69	2.43	15.18	4.83	12.14	50.70	1.99	4.87
846	Gluten Feed	9.46	90.54	1.94	4.05	25.32	3.42	7.67	52.19	1.90	1.91
847	Cotton Seed Meal	8.28	91.72	5.88	6.92	43.26	9.10	9.53	23.95	none	4.92
848	Hominy Chop	8.29	91.71	2.55	1.45	9.04	7.14	10.27	62.71	1.60	2.69
849	Ground Oats	9.95	90.05	3.29	1.84	11.50	5.52	10.38	49.36	0.91	1.50
850	Mixed Feed	9.70	90.30	4.32	3.26	20.36	6.12	10.86	48.64	1.08	3.68
893	Mixed Feed	10.55	89.45	4.28	3.45	21.59	6.25	9.46	47.87	1.34	3.93
909	Molasses	26.94	73.06	6.03	0.40	2.54	....	.....	64.49	20.33	53.44
952	Mueller's Molasses Grains	21.65	78.35	5.14	3.06	19.13	3.13	8.17	42.78	19.02	20.96
959	Mueller's Molasses Grains	21.68	78.32	5.11	2.85	17.82	2.50	8.17	44.82	19.54	22.60
000	Mueller's Molasses Grains. Average two samples.†	21.67	78.33	5.12	2.96	18.50	2.82	8.17	43.72	19.28	21.78

*Average of Samples 866 and 908.
†Average of Samples 952 and 959.

TABLE VI.

Composition of Dungs Collected During Digestion Experiments.
(Per Cent.)

Anal. No.	Steer No.	Water.	Dry Substance.	Ash.	Nitrogen.	Crude Protein.	Crude Fibr.	Ether Extract.	N. Free Extract.	Sugars Before Inversion.	Sugars After Inversion.
Period I.—Ration—Hay.											
829	1	83.30	16.70	1.34	0.19	1.19	5.85	0.51	7.81	0.135	0.116
830	2	80.78	19.22	1.52	0.26	1.59	6.22	0.67	9.22	0.285	0.299
831	3	79.85	20.15	1.61	0.27	1.69	6.47	0.75	9.63	0.163	0.169
832	4	80.47	19.53	1.53	0.24	1.52	6.54	0.71	9.23	0.187	0.202
Period II.—Ration—Hay + Sucrene.											
864	1	81.12	18.88	2.09	0.40	2.50	5.30	0.74	8.26	0.181	0.226
865	2	77.58	22.42	2.61	0.56	3.50	5.11	0.85	10.35	0.251	0.275
867	3	79.97	20.03	2.32	0.45	2.81	5.14	0.70	9.06	0.108	0.142
868	4	80.13	19.87	1.88	0.42	2.63	5.84	0.65	8.87	0.108	0.109
Period III.—Ration—Hay + Mixed Grain Feed.											
879	1	77.07	22.93	2.20	0.46	2.89	7.55	0.83	9.46	0.088	0.058
880	2	81.15	18.85	1.85	0.43	2.68	5.71	0.79	7.82	0.063	0.039
904	3	79.57	20.43	2.03	0.47	2.94	5.41	0.85	9.20	0.065	0.038
905	4	83.63	16.37	1.49	0.31	1.94	5.36	0.59	6.99	0.038	0.027
Period IV.—Ration—Hay + Mixed Grain Feed + Molasses.											
920	1	82.21	17.79	1.87	0.42	2.63	5.13	0.58	7.58	0.115	0.082
921	2	81.77	18.23	1.83	0.45	2.81	5.23	0.66	7.70	0.053	0.090
953	3	83.59	16.41	1.73	0.49	3.06	4.68	0.58	6.36	0.146	0.060
954	4	85.23	14.77	1.53	0.41	2.56	4.27	0.48	5.93	0.100	0.102
Period V.—Ration—Hay + Mueller's Molasses Grains.											
955	1	85.61	14.39	1.48	0.39	2.44	3.99	0.50	5.98	0.133	0.071
956	2	83.07	16.93	1.69	0.48	3.00	4.79	0.56	6.89	0.063	0.074
957	3	83.73	16.27	1.60	0.48	3.00	5.22	0.55	5.90	0.130	0.100
958	4	84.14	15.86	1.55	0.47	2.94	4.85	0.59	5.94	0.109	0.097
Period VI.—Ration—Hay + Molasses.											
970	1	83.12	16.88	1.70	0.30	1.90	5.82	0.64	6.82	0.106	0.112
971	2	80.17	19.83	1.99	0.38	2.38	6.69	0.78	7.99	0.120	0.112

WEIGHTS OF ANIMALS.

In feeding in work of this sort the main object is to give such amounts as would represent a full feed for animals doing a given work. The feeds used being principally of interest to dairymen were fed in amounts that would be about equal to a dairy ration.

TABLE VII.

Weights of Steers during Experiments.

Period	Steer No.	Weight at Beginning of Preliminary Period	Weight at Beginning of Digestion Period	Weight at End of Digestion Period	Ration
I	Steer 1	....	1221	1148	Hay
	Steer 2	....	1047	992	
	Steer 3	1103	1118	1089	
	Steer 4	1132	1160	1137	
II	Steer 1	1148	1222	1207	Hay and Sucrene
	Steer 2	992	1076	1077	
	Steer 3	1089	1168	1148	
	Steer 4	1137	1226	1235	
III	Steer 1	1207	1272	1245	Hay and Mixed Grain
	Steer 2	1077	1131	1148	
	Steer 3	1148	1155	1156	
	Steer 4	1235	1260	1265	
IV	Steer 1	1245	1301	1319	Hay and Mixed Grain and Molasses
	Steer 2	1148	1183	1185	
	Steer 3	1156	1183	1150	
	Steer 4	1265	1282	1280	
V	Steer 1	1319	1311	1315	Hay and Mueller's Molasses Grain
	Steer 2	1185	1167	1188	
	Steer 3	1150	1193	1219	
	Steer 4	1280	1273	1281	
VI	Steer 1	1315	1364	1246	Hay and Molasses
	Steer 2	1188	1127	1116	

It will be noted that on the whole the animals made slight gains.

I. THE EFFECT OF MOLASSES ON THE DIGESTIBILITY OF HAY.

The digestion coefficient of the hay was obtained, as this was the common factor and represented the roughage fed during all of the periods. It was planned to have the hay and the molasses periods follow one another, but through delays in transit the molasses did not reach us in time and thus caused the period of adding it to the hay to be deferred until the end and then could only be carried through with two steers.

The molasses used in this experiment was a very dark, heavy grade which was advertised in the agriculture papers and being placed on the market especially for stock feeding by J. S. Sills & Sons, of New York City. This molasses was diluted with an equal weight of water and sprinkled over the hay previous to feeding. The molasses was fed in small quantities at first and gradually increased. The animals seemed to like the molasses from the first and it seemed to agree with them very well. The hay used was a good quality of mixed timothy and clover with the timothy predominating.

The details of the amounts of food consumed during the two perods are given in tables 8 and 10, and the data from which the digestion coefficients were obtained are given in tables 9 and 11.

TABLE VIII.

Showing Consumption of Hay and Water during Digestion Period I. Hay Eaten and Water Drunk.

(Weight in Grams.)

PORTION OF PERIOD.	No. Days.	HAY EATEN.		WATER DRUNK.	
		Total.	Average Per Day.	Total.	Average Per Day.
Steer No. 1.					
Preliminary	12	93270	7773	359110	29926
Digestion	5	24220	4844	91760	18352
Steer No. 2.					
Preliminary	12	58080	4840	213650	17804
Digestion	5	18750	3750	56190	11238
Steer No. 3.					
Preliminary	14	95570	6826	319430	22816
Digestion	5	29960	5992	90290	18058
Steer No. 4.					
Preliminary	14	96140	6867	334690	23906
Digestion	5	29700	5940	91450	18290

TABLE IX.

Showing Digestibility of the Components of Mixed Hay—Digestion Period 1—Length of Preliminary Period 12 days, and Digestion Period 5 days.

(Weight in grams—453.6=1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 1											
Hay Fed	.....	26000.1	23389.6	1112.8	322.4	2015.0	8509.8	631.8	11120.2	603.2	795.6
Hay Refused	973	1780.1	1572.5	83.1	16.0	100.0	603.6	39.5	746.3	25.6	52.5
Total Eaten	.....	24220.1	21817.1	1029.7	306.4	1915.0	7906.1	592.3	10373.9	537.6	743.1
Total Excreted	829	82870.1	13839.3	1110.5	157.5	984.4	4848.0	422.6	6473.8	111.9	96.1
Digested	.....	....	7977.8	80.8	148.9	930.6	3058.2	170.7	3900.1	425.7	647.0
Per Cent. Digested	.....	....	36.56	....	48.60	48.60	38.68	28.82	37.62	79.18	87.06
Steer No. 2											
Hay Fed	.....	19000.0	17092.4	813.4	235.6	1472.5	6218.5	461.9	8126.1	440.8	581.4
Hay Refused	974	250.0	224.7	10.3	1.8	11.2	83.6	13.6	106.0	5.3	9.0
Total Eaten	.....	18750.0	16867.7	803.1	233.8	1461.3	6134.9	448.3	8020.1	435.5	572.4
Total Excreted	.....	48680.0	9356.3	739.8	126.5	790.6	3025.0	326.1	4474.8	138.7	145.6
Digested	.....	....	7511.4	63.3	107.3	670.7	3109.9	122.2	3545.3	296.8	426.8
Per Cent. Digested	.....	....	44.54	7.88	46.00	46.00	50.70	27.21	44.21	68.16	74.56
Steer No. 3											
Hay Fed	.....	30000.0	26988.0	1284.0	372.0	2325.0	9819.0	729.0	12831.0	696.0	918.0
Hay Refused	975	40.0	35.3	1.7	.4	2.5	14.1	1.1	15.9	.5	.9
Total Eaten	.....	29960.0	26952.7	1282.3	371.6	2322.5	9804.9	727.9	12815.1	695.5	917.1
Total Excreted	831	65100.0	13117.7	1048.0	175.7	1098.1	4211.5	488.2	6271.9	106.0	110.0
Digested	.....	....	13835.0	234.3	195.5	1224.4	5593.4	239.7	6543.2	589.5	807.1
Per Cent. Digested	.....	....	51.34	18.27	52.72	52.72	57.04	32.93	51.05	84.76	88.01
Steer No. 4											
Hay Fed	.....	30000.0	26988.0	1284.0	372.0	2325.0	9819.0	729.0	12831.0	696.0	918.0
Hay Refused	976	300.0	252.7	16.9	2.9	18.1	103.3	7.5	106.9	.7	6.6
Total Eaten	.....	29700.0	26735.3	1267.1	369.1	2306.9	9715.7	721.5	12724.1	695.3	911.4
Total Excreted	832	61630.0	12036.3	942.8	147.8	936.7	4030.5	437.5	5688.8	115.3	124.5
Digested	.....	....	14699.0	324.3	221.3	1370.2	5685.2	284.0	7035.3	580.0	786.9
Per Cent. Digested	.....	....	54.98	25.59	59.96	59.96	58.58	39.36	55.29	83.42	86.33
Average for 4 Steers	.....	....	48.35	17.25	44.32	44.32	51.25	32.08	47.04	78.88	83.89

TABLE X.

Showing Consumption of Hay and Molasses during Digestion, Period VI. Food Eaten and Water Drunk.

(Weight in Grams.)

PORTION OF PERIOD.	No. Days.	HAY EATEN.		MOLASSES EATEN.		WATER DRUNK.	
		Total.	Average Per Day.	Total.	Average Per Day.	Total.	Average Per Day.
Steer No. 1.							
Preliminary.....	9	44000	4889	9000	1000	194780	21642
Digestion.......	5	25000	5000	5000	1000	101070	20214
Steer No. 2.							
Preliminary	9	40172	4464	9000	1000	154890	17210
Digestion.......	5	24675	4935	5000	1000	85090	17018

TABLE XI.

Showing Digestibility of Hay and Molasses. Digestion Period VI. Length of Preliminary Period 9 Days and Digestion Period 5 Days.

(Weight in grams—453.6 grams=1 pound.)

	Anal. No.	Fresh Substance.	Dry Substance.	Ash.	Nitrogen.	Crude Protein.	Crude Fiber.	Ether Extract.	N-Free Extract.	Sugars Before Inv.	Sugars After Inv.
Steer No. 1.											
Hay eaten	xxx	25000.0	21925.0	960.0	302.5	1890.0	7892.0	567.5	10615.5	190.0	317.5
Molasses eaten	909	5000.0	3653.0	301.5	20.0	125.0	....	....	....	1016.5	2672.0
Total eaten	......	30000.0	25578.0	1261.5	322.5	2015.0	7892.0	567.5	10615.5	1206.5	2989.5
Total excreted	970	62540.0	10557.0	1063.0	187.6	1172.5	3640.0	400.5	4281.0	66.3	70.0
Digested	......	....	15021.0	198.5	134.9	842.5	4252.0	167.0	6334.5	1140.2	2919.5
Per cent. digested	......	....	58.73	15.74	41.83	41.83	53.88	29.43	59.68	94.67	97.66
Steer No. 2.											
Hay fed	xxx	25000.0	21925.0	960.0	302.5	1890.6	7892.0	567.5	10616.9	190.0	317.5
Molasses	909	5000.0	3653.0	301.5	20.0	125.0	....	....	3226.5	1016.5	2672.0
Total fed	......	30000.0	25578.0	1261.5	322.5	2015.6	7892.0	567.5	13843.4	1206.5	2989.5
Hay and Molasses refused	978	390.0	321.9	19.5	3.7	23.1	153.0	3.0	123.3	2.3	2.7
Total eaten	......	29610.0	25256.1	1242.0	318.8	1992.5	7739.0	564.5	13720.1	1204.2	2986.8
Total excreted	971	54470.0	10822.0	1084.0	207.0	1293.8	3644.0	424.8	4352.0	65.4	61.0
Total digested	......	....	14434.1	158.0	111.8	698.7	4095.0	139.7	9368.1	1138.8	2925.8
Per cent. digested	......	....	56.64	12.52	34.67	34.67	51.90	24.62	67.68	94.59	97.87
Average for 2 steers	......	....	57.58	14.13	38.25	38.25	52.89	27.02	63.68	94.63	97.76

Bringing the above results together for comparison we have,

TABLE XII.

Digestibility of the Components of Hay.
(Per Cent.)

	Dry Substance	Ash	Crude Protein	Crude Fiber	N-Free Extract	Fat	Sugar before Inv.	Sugar after Inv.
Hay (average for 4 steers) ..	48.4	17.2	44.3	51.3	47.0	32.1	78.9	84.0
Hay (average for 2 steers) ..	40.6	3.9	47.3	44.7	40.9	28.0	73.7	80.8
Hay and Molasses (average for 2 steers)	57.6	14.1	38.3	52.9	63.7	27.0	94.6	97.7
Effect of Molasses	+17.0	+10.2	−9.0	+8.2	+22.8	—1.0	+20.9	+16.9

From the above figures when studied in connection with those in table 11 it will be noticed that the general effect of the molasses was to increase the digestibility of the hay. The most marked effect seemed to be upon the starch and sugar compounds of the hay, and it is probable that the salts in the molasses and the ferments which it introduced exerted a marked influence in breaking up the more staple Nitrogen-free extract compounds in the hay.

If we assume that all of the dry substance of the molasses was digestible it would still allow about one-third of the increase to be credited to the greater digestibility of the hay as caused by the presence of the molasses. This was produced by the consumption of about 2 lbs. of molasses per day, or at a cost of about 2 cents.

II. THE EFFECT OF MOLASSES ON A MIXED GRAIN RATION.

So far as the composition of the molasses feeds on the market are advertised or known, they are made up of a variety of grains and mostly of those which are relatively rich in protein. With a view of using a mixture that might somewhat imitate those on the market and at least represent the feeds most commonly in use by dairymen, the following mixture of grain was made up for periods III and IV.

Wheat Bran	200	lbs.
Gluten Feed	120	"
Cotton Seed Meal	180	"
Hominy Chop	50	"
Ground Oats	200	"
Total	750	"

This was made up in two lots. Mixture (sample) No. 850 was fed with the hay during period III. as an insufficient quantity was made up to last for the two periods, another lot was mixed up in the same proportions (sample No. 193), and fed during period IV. The two analyses as given in table No. 5 will show that there was no material difference in the two mixtures. In period IV molasses was mixed with the grain just previous to feeding. The quantity of molasses fed each time was just one-third the weight of the grain or one-fourth or 25 per cent of the total. Thus the ration for this period imitated a molasses feed containing 25 per cent of molasses. The hay used during these periods was the same as fed during period I. It was aimed to feed the same quantity but the animals failed to eat quite as much after the grain was added to the ration.

The details of the amounts of food consumed during period III. and IV. will be found in tables 13 and 15, and the data from which the digestion coefficients are obtained are given in tables 14 and 16.

TABLE XIII.

Showing Consumption of Hay, Grain and Water during Digestion Period III.

(Food eaten and water drunk.)

Digestion of Period	No. Days	Hay Eaten		Grain Eaten		Water Drunk	
		Total	Average Per Day	Total	Average Per Day	Total	Average Per Day
Steer No. 1							
Preliminary . .	9	28900	3211	54000	6000	370520	41169
Digestion	5	20830	4166	30000	6000	207950	41590
Steer No. 2							
Preliminary . .	9	34700	3864	54000	6000	252220	28024
Digestion	5	19790	3958	30000	6000	177710	35542
Steer No. 3							
Preliminary . .	9	35750	3972	54000	6000	306770	34086
Digestion	5	19910	3982	30000	6000	153060	30612
Steer No. 4							
Preliminary . .	9	48900	5433	54000	6000	370520	41169
Digestion	5	20830	4166	30000	6000	207950	41590

TABLE XIV.

Showing Digestibility of Mixed Grain Ration. Digestion Period III. Length of Preliminary Period 9 days, and Digestion Period 5 days.

(Weight in grams—453.6 grams=1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 1											
Hay Fed	......	21000.0	18640.0	905.1	266.7	1666.9	6245.0	959.7	8863.3	487.2	527.1
Hay Refused	973	170.0	150.2	8.0	1.5	9.6	57.6	3.8	71.2	2.4	5.0
Hay Eaten	......	20830.0	18489.8	897.1	265.2	1657.3	6187.4	955.9	8792.1	484.8	522.1
Grain Eaten	850	30000.0	27090.0	1296.0	978.0	6112.5	3258.0	1836.0	13587.5	324.0	1104.0
Total Eaten	......	50830.0	45579.8	2193.1	1243.2	7769.8	9445.4	2791.9	22379.6	808.8	1626.1
Total Excreted	879	115800.0	26552.9	2547.5	532.7	3329.4	8742.0	961.1	10972.9	102.8	67.2
Total Digested	......	....	19026.9	none	710.5	4440.4	703.4	1830.8	11406.7	706.0	1558.9
Hay Digested	......	....	6759.9	....	128.9	805.4	2393.2	276.0	3308.0	383.8	454.5
Grain Digested	......	....	12267.0	none	581.6	3635.0	none	1554.8	8098.7	322.2	1104.4
Per Cent. Digested	......	....	45.28	none	59.36	59.36	none	84.64	59.60	99.4	100.0
Steer No. 2											
Hay Fed	......	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	974	210.0	188.8	8.7	1.5	9.5	70.1	11.4	89.1	4.4	7.5
Hay Eaten	......	19790.0	17563.2	854.3	252.2	1578.0	5877.9	902.6	8351.4	359.6	494.5
Grain Eaten	850	30000.0	27090.0	1296.0	978.0	6112.5	3258.0	1836.0	13587.5	324.0	1104.0
Total Eaten	......	49790.0	44653.2	2150.3	1230.5	7690.5	9135.9	2838.6	21938.9	683.6	1598.5
Total Excreted	880	91390.0	17225.0	1690.6	392.9	2455.6	5218.0	722.0	7138.8	57.6	35.6
Total Digested	......	....	27428.2	459.7	837.6	5234.9	3917.9	2116.6	14800.1	626.0	1562.9
Hay Digested	......	....	7820.0	67.3	116.2	725.9	2980.0	246.0	3692.0	245.1	368.7
Grain Digested	......	....	19608.2	392.4	721.4	4409.0	837.9	1870.6	11108.1	380.9	1194.2
Per Cent. Digested	......	....	72.38	30.28	73.76	73.76	28.79	101.89	86.60	117.5	108.2

Steer No. 3											
Hay Fed	......	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	975	90.0	79.4	3.9	1.0	6.2	31.8	2.5	35.0	1.1	2.0
Hay Eaten	......	19910.0	17672.6	858.1	253.0	1581.3	5916.2	911.5	8405.5	362.9	500.0
Grain Eaten	850	30000.0	27090.0	1296.0	978.0	6112.5	3258.0	1836.0	13587.5	324.0	1104.0
Total Eaten	......	49910.0	44762.6	2151.1	1231.0	7693.8	9174.2	2747.5	21993.0	686.9	1604.4
Total Excreted	904	83950.0	17151.0	1704.0	394.5	2465.6	4541.5	713.6	7726.3	54.6	31.9
Total Digested	.....	....	27611.6	450.1	835.5	5228.2	4632.7	2033.9	14266.7	632.3	1572.1
Hay Digested	......	....	9073.0	156.8	133.4	833.6	3374.7	300.2	4290.5	307.6	440.0
Grain Digested	......	....	18538.6	293.3	702.1	4394.6	1258.0	1733.7	9976.2	324.7	1132.1
Per Cent. Digested	......	....	68.44	22.63	71.79	71.79	38.62	94.42	73.43	100.2	102.5
Steer No. 4											
Hay Fed	......	21000.0	18640.0	905.1	266.7	1666.9	6245.0	959.7	8863.3	487.2	527.1
Hay Refused	976	170.0	143.3	9.6	1.7	10.6	58.6	4.3	60.2	.4	3.7
Hay Eaten	......	20830.0	18496.7	895.5	265.0	1656.3	6186.4	955.4	8803.1	486.8	523.4
Grain Eaten	850	30000.0	27090.0	1296.0	978.0	6112.5	3258.0	1836.0	13587.5	324.0	1104.0
Total Eaten	......	50830.0	45586.7	2191.5	1243.0	7767.8	9444.4	2791.4	22390.6	810.8	1627.4
Total Excreted	905	116610.0	19088.3	1737.5	361.5	2259.4	6250.0	688.0	8153.5	44.3	31.5
Total Digested	......	....	25498.4	454.0	881.5	5509.4	3194.4	2103.4	14237.2	766.5	1595.9
Hay Digested	......	....	10169.0	202.3	158.9	992.8	3624.0	376.1	4866.0	406.2	451.9
Grain Digested	......	....	15329.4	251.7	622.6	4517.6	none	1727.3	9371.2	360.3	1144.0
Per Cent. Digested	......	....	73.74	19.44	63.66	63.66	none	94.08	68.98	111.2	103.6
Average for 4 steers	......	....	64.96	18.09	67.15	67.15	16.85	93.26	72.15	107.1	103.6

TABLE XV.

Showing Consumption of Hay, Grain, Molasses and Water during Digestion Period IV.

(Food eaten and water drunk.)

Portion of Period	No. Days	HAY EATEN		GRAIN EATEN		MOLASSES EATEN		WATER DRUNK	
		Total	Average Per Day	Total	Average Per Day	Total	Average Per Day	Total	Average Per Day
Steer No. 1									
Preliminary	9	40350	4483	54000	6000	12500	1389	342870	38097
Digestion..........	5	19620	3924	30000	6000	10000	2000	188620	37724
Steer No. 2									
Preliminary	9	35610	3957	54000	6000	12500	1389	294890	32766
Digestion..........	5	19790	3958	30000	6000	10000	2000	170080	34016
Steer No. 3									
Preliminary	9	34690	3854	54000	6000	14150	1572	297180	33030
Digestion..........	5	15180	3036	30000	6000	10000	2000	169880	33976
Steer No. 4									
Preliminary	9	44440	4938	54000	6000	14150	1461	363290	40366
Digestion..........	5	19880	3976	30000	6000	10000	2000	184300	36860

TABLE XVI.

Showing the Digestibility of Mixed Grain Ration and Molasses. Digestion Period IV—Length of Preliminary Period 9 days and the Digestion Period 5 days.

(Weight in grams—453.6 grams = 1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 1											
Hay Fed	xxx	20000.0	17552.0	862.0	254.0	1587.0	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	973	380.0	335.7	17.7	3.4	21.3	128.8	8.4	159.5	5.5	11.2
Hay Eaten	.....	19620.0	17416.3	844.3	250.6	1566.2	5819.2	905.6	8281.0	358.5	490.8
Grain Eaten	893	30000.0	26835.0	1284.0	1035.0	6468.8	2838.0	1875.0	14369.2	402.0	1179.0
Molasses	909	10000.0	7306.0	603.0	40.0	250.0	....	....	6449.0	2033.0	5344.0
Total Eaten	.....	59620.0	51557.3	2731.3	1325.6	8284.0	8657.2	2780.6	29099.2	2793.5	8013.8
Total Excreted	920	96800.0	17221.0	1810.0	406.5	2540.6	4965.6	561.4	7343.4	111.3	79.3
Total Digested	.....	....	34336.3	921.3	919.1	5743.4	3691.6	2219.2	21755.8	2682.2	6934.5
Hay Digested	.....	....	6367.0	....	120.8	761.3	2251.0	261.0	3115.5	283.9	427.6
Grain and Molasses Digested	.....	....	27969.3	921.3	798.3	4982.1	1440.6	1958.2	18640.3	2398.3	6506.9
Grain and Molasses Eaten	.....	40000.0	34141.0	1887.0	1075.0	6718.8	2338.0	1875.0	20818.2	2435.0	6523.0
Per Cent. Digested	.....	....	81.92	48.83	74.23	74.23	61.59	104.42	89.54	98.5	99.7
Steer No. 2											
Hay Fed	xxx	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	974	210.0	188.8	8.7	1.5	9.4	70.1	11.4	89.2	4.4	7.5
Hay Eaten	.....	19790.0	17563.2	853.3	252.5	1576.1	5877.9	902.6	8351.3	359.6	494.5
Grain Eaten	893	30000.0	26835.0	1284.0	1035.0	6468.8	2838.0	1875.0	14369.2	402.0	1179.0
Molasses	909	10000.0	7306.0	603.0	40.0	250.0	....	....	6449.0	2033.0	5344.0
Total Eaten	.....	59790.0	51704.2	2740.3	1327.5	8294.9	8715.9	2777.6	29169.5	2794.6	7017.5
Total Excreted	921	96180.0	17534.0	1760.0	432.8	2705.5	5030.0	634.8	7404.2	51.0	86.6
Total Digested	.....	....	34170.2	980.3	894.7	5589.9	3685.9	2142.8	21765.3	2743.6	6930.9
Hay Digested	.....	....	7822.0	67.2	116.2	726.3	2980.0	245.6	3692.0	245.1	368.7
Grain and Molasses Digested	.....	....	26348.2	913.1	778.5	4863.6	705.9	1897.2	18073.3	2498.5	6562.2
Grain and Molasses Eaten	.....	....	34141.0	1887.0	1075.0	6918.8	2338.0	1875.0	20813.2	2435.0	6523.0
Per Cent. Digested	.....	....	77.18	48.39	72.42	72.42	30.19	101.18	86.82	102.6	100.6

TABLE XVI.—CONTINUED.

Showing the Digestibility of Mixed Grain Ration and Molasses. Digestion Period IV—Length of Preliminary Period 9 days and the Digestion Period 5 days.

(Weight in grams—453.6 grams=1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 3											
Hay Fed	xxx	17000.0	15088.0	732.6	215.9	1349.2	5054.0	776.8	7175.4	309.4	426.7
Hay Refused	975	1820.0	1605.9	79.2	19.8	123.7	643.0	50.6	709.4	23.1	40.8
Hay Eaten	.....	15180.0	13482.1	663.4	196.1	1225.5	4411.0	726.2	6466.0	286.3	385.9
Grain Eaten	893	30000.0	26835.0	1284.0	1035.0	6468.8	2838.0	1875.0	14369.2	402.0	1179.0
Molasses Eaten	909	10000.0	7306.0	603.0	40.0	250.0	....	....	6449.0	2033.0	5344.0
Total Eaten	.....	55180.0	47623.1	2550.4	1271.1	7943.3	7240.0	2601.2	27284.2	2721.3	6908.9
Total Excreted	953	94290.0	15472.0	1631.0	462.0	2887.5	4412.5	546.9	5994.1	137.7	56.6
Total Digested	.....	....	32151.1	919.4	809.1	5055.8	2836.5	2054.3	21290.1	2583.6	6852.3
Hay Digested	.....	....	6291.7	121.2	103.4	646.3	2516.0	239.0	3300.9	242.6	339.6
Grain and Molasses Digested	.....	....	25229.4	798.2	705.7	4409.5	320.5	1815.3	17989.2	2341.0	6512.7
Grain and Molasses Eaten	.....	....	34141.0	1887.0	1075.0	6718.8	3338.0	1875.0	20818.2	2435.0	6523.0
Per Cent. Digested	.....	....	73.90	42.30	65.65	65.65	13.71	96.82	86.42	96.1	99.8
Steer No. 4											
Hay Fed	xxx	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	976	120.0	101.1	6.7	1.2	7.3	41.3	3.0	42.8	.3	2.6
Hay Eaten	.....	19880.0	17650.9	855.3	252.8	1580.2	5906.7	911.0	8397.7	363.7	499.4
Grain Eaten	893	30000.0	26835.0	1284.0	1035.0	6468.8	2838.0	1875.0	14369.2	402.0	1179.0
Molasses Eaten	909	10000.0	7306.0	603.0	40.0	250.0	....	....	6449.0	2033.0	5344.0
Total Eaten	.....	59880.0	51791.9	2742.3	1327.8	8298.0	8744.7	2786.0	29215.9	2798.7	7022.4
Total Excreted	954	93410.0	13807.0	1429.0	383.0	2393.8	3988.5	448.3	5547.4	93.4	95.3
Total Digested	.....	....	37984.9	1313.3	944.8	5904.2	4756.2	2337.7	23668.5	2705.3	6927.1
Hay Digested	.....	....	9704.5	218.9	151.6	947.5	3460.1	358.6	4643.1	303.4	431.1
Grain and Molasses Digested	.....	....	28280.4	1094.4	793.2	4956.7	1296.1	1979.1	19025.4	2401.9	6496.0
Grain and Molasses Eaten	.....	....	34141.0	1887.7	1075.0	6718.8	2338.0	1875.0	20818.2	2435.0	6523.0
Per Cent. Digested	.....	....	82.84	58.00	73.79	73.79	55.44	105.55	91.39	98.6	99.6
Average for 4 steers	.....	....	78.96	49.38	71.52	71.52	40.23	101.99	88.55	98.9	99.9

Bringing the above results together for comparison we have these set forth in table 17.

TABLE XVII.

Digestibility of Mixed Grain Ration with and without Molasses.
(Average of results with 4 steers in per cents.)

	Dry Substance	Ash	Crude Protein	Crude Fiber	N-Free Extract	Fat	Sugar before Inv.	Sugar after Inv.
Mixed Grain..............	64.9	18.1	67.1	16.8	72.1	93.3	107.1	103.6
Mixed Grain and Molasses	78.9	49.4	71.5	40.2	88.6	102.0	98.9	99.9
Gain produced by Molasses	14.0	31.3	4.4	23.4	15.5	—8.7	......	......

The above results would seem to indicate that the molasses exerted a beneficial influence and caused an increase in the digestibility of the grains.

The instances where the digestion coefficients run over 100 of course represent an impossibility and may be due to several causes or a combination of them. A portion is due no doubt to oxidation products in the dung, which do not exist in the feeds; again, several feeds when brought together often contribute towards the digestibility of each other and thus the hay was probably more digestible in the presence of the grain than when fed alone. Some of the difference is also probably due to the method of analysis not being adapted to the dungs.

When considered as to the increased digestibility of the total dry matter the results agree fairly closely with those obtained for hay and was produced at about the same cost.

III. THE DIGESTIBILITY OF "SUCRENE" DAIRY FEED.

Sucrene dairy feed is probably more extensively used than any other molasses feed on the market. It is manufactured by some patented process which claims to convert the molasses into a sugar or a sugar-like substance. The base of the feed is made up of a mixture of a variety of grains.

"Sucrene" is generally much liked by animals but occasionally they do not seem to find it palatable at first; but by commencing to feed it in small quantities and gradually increasing the amount it is but a short time until the animals acquire the taste and become quite fond of it.

Sucrene represents a distinct class of molasses feeds in that it is much drier than most others, is not much inclined to cake and it also has good keeping qualities. The sucrene used in this experiment represented two lots, one bought from a carload shipped to Hyattsville Station, and a second lot bought through the Washington dealers in this feed.

After the completion of the digestion experiments sucrene was fed for some time to the steers and they continued to eat a full ration of it with relish, did well on it and showed no bad effects whatever.

The details of the amounts of food consumed and the results of the determination of the digestibility are set forth in tables No. 18 and No. 19.

TABLE XVIII.

Showing Consumption of Hay, Sucrene and Water during Digestion Period II.

(Rations eaten and water drunk.)

Portion of Period	No. Days	Hay Eaten		Sucrene Eaten		Water Drunk	
		Total	Average Per Day	Total	Average Per Day	Total	Average Per Day
Steer No. 1							
Preliminary	9	38450	4272	54000	6000	310040	34449
Digestion	5	19880	3976	30000	6000	158180	31636
Steer No. 2							
Preliminary	9	15300	1700	54000	6000	207970	23108
Digestion	5	9870	1974	30000	6000	93110	18622
Steer No. 3							
Preliminary	9	46360	5151	52000	5778	271410	30157
Digestion	5	22850	4570	30000	6000	161120	32424
Steer No. 4							
Preliminary	9	47610	5290	54000	6000	337170	37463
Digestion	5	26000	5200	30000	6000	182440	36488

TABLE XIX.

Showing Digestibility of Sucrene. Period II—Length of Preliminary Period 9 days, and Digestion Period 5 days.
(Weight in grams—453.6 grams = 1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 1											
Hay Fed	xxx	20000.0	17752.0	862.0	254.0	1588.0	5948.0	914.0	8440.0	364.0	502.0
Hay Refused	973	120.0	106.0	5.6	1.1	6.7	40.7	2.7	50.3	1.7	3.5
Hay Eaten	......	19880.0	17646.0	856.4	252.9	1581.3	5907.3	911.3	8389.7	362.3	498.5
Sucrene Eaten	844	30000.0	26460.0	2085.0	813.0	4981.3	2880.0	2064.0	14458.7	3258.0	3768.0
Total Eaten	......	49880.0	44115.0	2941.4	1065.9	6562.6	8787.3	2975.3	22848.4	3620.3	4266.5
Total Excreted	864	100020.0	18885.0	2090.5	400.0	2500.0	5300.0	740.0	8260.0	181.0	226.0
Digested	......	....	25230.0	850.9	665.9	4062.6	3487.3	2235.3	14588.4	3439.3	4040.5
Hay Digested	......	....	6451.4	....	122.9	768.1	2284.9	262.6	3156.2	286.9	434.0
Sucrene Digested	......	....	18778.6	850.9	543.0	3294.5	1202.4	1972.7	11432.2	3152.4	3606.5
Per Cent. Digested	......	....	70.96	40.77	66.79	66.79	41.56	95.59	79.06	96.76	95.70
Steer No. 2											
Hay Fed	xxx	10000.0	8876.0	431.0	127.0	794.0	2974.0	457.0	4220.0	182.0	251.00
Hay Refused	974	130.0	116.9	5.4	.9	5.8	43.4	7.1	55.2	2.7	4.70
Hay Eaten	......	9870.0	8759.1	425.6	126.1	788.2	2930.6	449.9	4164.8	179.3	246.3
Sucrene Eaten	844	30000.0	26304.0	1944.0	795.0	4974.0	3039.0	1260.0	15087.0	3258.0	3768.0
Total Eaten	......	39870.0	35063.1	2369.6	921.1	5762.2	5969.6	1709.9	19251.8	3437.3	4014.3
Total Excreted	865	61340.0	13752.0	1601.0	343.5	2146.8	3134.0	521.4	6348.8	153.9	168.7
Digested	......	....	21311.1	768.6	577.6	3615.4	2835.6	1188.5	12903.0	3283.4	3845.6
Hay Digested	......	....	3901.3	33.5	58.0	362.5	1485.8	122.4	1841.3	122.2	183.7
Sucrene Digested	......	....	17409.8	735.1	519.6	3252.9	1349.8	1066.1	11061.7	3161.2	3661.9
Per Cent. Digested	......	....	66.19	37.82	65.28	65.28	44.42	84.62	73.34	96.89	97.15

TABLE XIX—CONTINUED.

Showing Digestibility of Sucrene. Period II—Length of Preliminary Period 9 days, and Digestion Period 5 days.

(Weight in grams—453.6 grams=1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 3											
Hay Fed	xxx	23000.0	20414.0	991.0	292.1	1825.6	6840.0	1051.0	9706.4	418 6	577.3
Hay Refused	975	150 0	132.4	6.5	1.6	10.0	53.0	4.2	58 7	1.9	3 4
Hay Eaten	......	22850.0	20281.6	984.5	290.5	1835.6	6787.0	1046.8	9647.7	415.7	573.9
Sucrene Eaten	844	30000.0	26304.0	1944.0	795.0	4974.0	3039 0	1260.0	15087.0	3258 0	3768.0
Total Eaten	......	52850.0	46585.6	2928 5	1035.5	6809.6	9826.0	2306.8	24734 7	3673.7	4341.9
Total Excreted	867	86080.0	17240.0	1997.0	387.3	2420.6	4424.0	602.5	7795.9	93 0	122.2
Digested	......	....	29345.6	931.5	698.2	4389.0	5402.0	1704.3	16938.8	3580.7	4219.7
Hay Digested	......	....	10412.6	179.9	153.2	957.5	3871 3	344.7	4925.2	352.2	505 1
Sucrene Digested	......	....	18933.0	751.6	545 0	3431.5	1530.7	1359.6	12013.6	3228.5	3714.6
Per Cent. Digested	......	....	71.98	38.67	68.56	68.56	50.36	107.9	79.64	99.10	98.56
Steer No. 4											
Hay Eaten	xxx	26000.0	23075.0	1120.5	330 2	2064 2	7732.0	1188.0	10970.3	473.2	652.6
Sucrene Eaten	844	30000.0	26304.0	1944.0	795.0	4974.0	3039.0	1260.0	15087.0	3250.0	3768.0
Total Eaten	......	56000.0	49379.0	3064.5	1125.2	7038.2	10771.0	2448 0	26057.3	3731.2	4420.6
Excreted	868	107210.0	21300 0	2015.6	450 3	2819.6	6260.8	696 8	9507.2	115 8	116.9
Digested	......	....	28079.0	1048.9	674.9	4218 6	4510.2	1751.2	16550.1	3615.4	4303.7
Hay Digested	......	....	12686.6	286.7	198.0	1237.5	4529.4	467.6	6065 5	394.6	563 5
Sucrene Digested	......	....	15392.4	762 2	476.9	2981.1	....	1283.6	10484 6	3220.8	3740 2
Per Cent. Digested	......	....	58 51	39.21	59.99	59 99	....	101 85	69 51	99.08	99.26
Average for 4 steers	......	....	66.91	39.12	65 15	65.15	34.08	97.49	75.39	97.96	97.67

IV. THE DIGESTIBILITY OF MUELLER'S MOLASSES GRAINS.

Mueller's Molasses Grains is represented to be a mixture of molasses, distillers' and brewers' grains. It appears to be simply the molasses absorbed by the grain and as far as any claims set forth in the advertising matter this would seem to be the process employed in its manufacture. Mueller's Molasses Grains represents a different class of molasses feeds from the Sucrene. It is rather high in moisture and inclined to cake. The amount of moisture which it contains may cause it to ferment. It does not break very readily and thus is not as easy to handle in feeding as is desirable.

The details of the amount of food consumed and the data from which the digestion coefficients were determined are given in tables 20 and 21.

The feed used in these experiments was purchased from the Washington, D. C., dealer. The steers when fed for some time on this feed showed signs of bloating and refused to eat it. There seemed to be an excessive amount of gas formed which probably was produced by an acid fermentation in the stomach. This condition occurred with three out of the four steers under test.

TABLE XX.

Showing Consumption of Hay, Mueller's Molasses Grains and Water. Digestion Period V.

(Food eaten and water drunk.)

Portion of Period	No. Days	HAY EATEN		GRAIN EATEN		WATER DRUNK	
		Total	Average Per Day	Total	Average Per Day	Total	Average Per Day
Steer No. 1							
Preliminary	9	35610	3957	35100	3900	301810	33534
Digestion	5	19800	3960	30000	6000	194840	38968
Steer No. 2							
Preliminary	9	35620	3958	33340	3704	264460	29384
Digestion	5	19590	3918	30000	6000	167560	33512
Steer No. 3							
Preliminary	9	31480	3497	43500	4833	298000	33111
Digestion	5	19840	3968	30000	6000	186650	37330
Steer No. 4							
Preliminary	9	35920	3991	43500	4833	307220	34135
Digestion	5	20000	4000	20000	6000	189560	37912

TABLE XXI.

Showing the Digestibility of Mueller's Molasses Grains. Digestion Period V—Length of Preliminary Period 9 days, Digestion Period 5 days.

(Weight in grams — 453.6 grams = 1 pound.)

	Anal. No.	Fresh Substance	Dry Substance	Ash	Nitrogen	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Sugars before Inv.	Sugars after Inv.
Steer No. 1											
Hay Fed	xxx	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	973	200.0	176.7	9.3	1.8	11.2	67.8	4.4	82.8	2.9	5.9
Hay Eaten	......	19800.0	17575.3	852.7	242.2	1576.3	5880.2	909.6	8356.7	361.1	496.1
Grain Eaten	000	30000.0	23499.0	1536.0	888.0	5540.0	2451.0	846.0	13126.0	5784.0	6534.0
Total Eaten	......	49800.0	41074.3	2388.7	1130.2	7116.3	8331.2	1758.6	21482.7	6145.1	7030.1
Total Excreted	955	98360.0	14154.4	1455.8	383.6	2397.5	3924.5	491.8	5884.4	130.8	69.8
Total Digested	......	....	26920.3	932.9	746.6	4718.8	4406.7	1263.8	15598.3	6014.3	6960.3
Hay Digested	......	....	6425.5	....	117.7	735.6	2274.5	262.1	3143.8	285.9	431.8
Grain Digested	......	....	20494.8	932.9	628.9	3983.2	2132.2	1001.7	12454.5	5728.4	6528.5
Per Cent. Digested	......	....	87.22	60.74	70.82	70.82	86.99	118.40	94.89	99.0	99.9
Steer No. 2											
Hay Fed	xxx	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.5	364.0	502.0
Hay Refused	974	410.0	368.7	16.9	3.0	18.7	136.9	22.3	173.9	8.6	14.7
Hay Eaten	......	19590.0	17383.3	845.1	251.0	1568.8	5811.1	891.7	8266.6	355.4	487.3
Grain Eaten	000	30000.0	23499.0	1536.0	888.0	5540.0	2451.0	846.0	13126.0	5784.0	6534.0
Total Eaten	......	49590.0	40882.3	2381.1	1139.0	7108.8	8262.1	1737.7	21392.6	6139.4	7021.3
Total Excreted	956	86800.0	19505.0	1947.0	553.0	3456.0	5518.0	554.2	7929.8	54.7	64.2
Total Digested	......	....	21377.3	434.1	586.0	3652.8	2744.1	1183.5	13462.8	6084.7	6957.1
Hay Digested	......	....	7742.5	6666	115.5	711.9	2946.2	242.6	3654.7	242.2	363.3
Grain Digested	......	....	13634.8	434.1	470.5	2930.9	....	830.9	9808.1	5842.5	6593.8
Per Cent. Digested	......	....	58.02	28.26	52.92	52.92	....	98.22	74.72	101.0	102.5

Steer No. 3												
Hay Fed	xxx	20000.0	17752.0	862.0	254.0	1587.5	5948 0	914.0	8440 5	364.0	502.0
Hay Refused	975	160.0	141 2	7.0	1.7	10.6	56 5	4 5	62 6	2.0	3.6
Hay Eaten		19840 0	17610.8	855 0	252.3	1576.9	5891.5	908.5	8377.9	362.0	498.4
Grain Eaten	000	30000 0	23499.0	1536.0	888.0	5540.0	2451.0	846.0	13126.0	5784.0	6534.0
Total Eaten		49840.0	41109.8	2391.0	1140.3	7116.9	8342.5	1754.5	21503.9	6146.0	7032.4
Total Excreted	957	84710.0	19208.0	1888.8	566.6	3541.3	6162.2	649.3	6966.4	110.1	84.7
Total Digested			21801.8	502.2	573.7	3575.6	2180.3	1105.2	14537.5	6035.9	6947.7
Hay Digested			9041.4	156.2	133.0	831.3	3106.0	299.2	5068.6	306.8	438.6
Grain Digested			12760.4	346.0	440.7	2744.3		806.0	9468.9	5729.1	6509.1
Per Cent. Digested			54.30	22.53	49.63	49.63	none	95.28	72.14	99.0	99.6
Steer No. 4												
Hay Eaten	xxx	20000.0	17752.0	862.0	254.0	1587.5	5948.0	914.0	8440.0	364.0	502.0
Grain Eaten	000	30000.0	23499.0	1536.0	888.0	5540.0	2451.0	846.0	13126.0	5784.0	6534.0
Total Eaten		50000.0	41251.0	2398.0	1142.0	7127.5	8399.0	1760.0	21566.0	6148.0	7036.0
Total Excreted	958	89840.0	17653.0	1725.2	523.2	3270.0	5398.0	656.8	6612.0	97.9	89 6
Total Digested			23598.0	672.8	495.4	3086.2	3001.0	1103.2	14954.4	6050.1	6946.4
Hay Digested			6490.1		123.4	771.3	2300.7	263.4	3175.1	303.7	433.4
Grain Digested			17107.9	672.8	495.4	3086.2	700.3	839.8	11978.9	5746.4	6513 0
Per Cent. Digested			72.82	43.81	55.79	55.79	28.56	99.27	91.26	99 3	99.7
Average for 4 steers			68.09	38.84	57.29	57.29	28 89	102.79	83.25	99.8	100.4

SUMMARY OF RESULTS.

In order that the results may be studied with greater ease and a comparison of the rations made, the averages of the results obtained are brought together in table No. 22.

TABLE XXII.

Showing average coefficients of Digestibility obtained in the Experiments together with those of Wheat Bran for comparison.

(Average of results obtained with 4 steers.)

	Dry Substance	Ash	Crude Protein	Crude Fiber	N-Free Extract	Fat	Sugars before Inv.	Sugars after Inv.
	%	%	%	%	%	%	%	%
1. Hay (Average of 4 steers).........	48.4	17.2	44.3	51.3	47.0	32.1	78.9	84.0
2. Hay (Average of 2 steers)...........	40.6	3.9	47.3	44.7	40.9	28.0	73.7	80.8
3. Hay and Molasses (Aver. of 2 steers)	57.6	14.1	38.3	52.9	63.7	27.0	94.6	97.7
4. Mixed Grain........	64.9	18.1	67.1	16.8	72.1	93.3	107.1	103.6
5. Mixed Grain and Molasses.........	78.9	49.4	71.5	40.2	88.6	102.0	98.9	99.9
6. Sucrene	66.9	39.1	65.2	34.1	75.4	97.5	97.9	97.7
7. Mueller's Molasses Grains...........	68.1	38.8	57.3	28.9	83.2	102.8	99.8	100.4
Wheat Bran......	67.3	47.1	82.3	25.1	74.6	54.7	....	....

These results show that the addition of molasses to a ration has a tendency to increase the digestibility of both hay and grain feeds. This coupled with the generally observed fact that molasses contributes toward making feeds more palatable and also acts as an appetizer gives to molasses a relatively high place as a stock food and makes it more valuable than its analysis alone would indicate.

The results obtined with Sucrene and Mueller's Molasses Grains when compared with those obtained for the mixed grain ration used, show quite evidently that the molasses which they contain have contributed toward making them more digestible and giving them a higher feeding value than they would have had without the molasses. The mixed grain ration used contained a greater variety of grains than is used by most dairymen and probably average well with any in quality, yet both the Sucrene and Mueller's Molasses Grains showed a higher digestibility.

In studying these figures the point is noticed that the protein is sometimes not so digestible in the presence of molasses, and this suggests the thought that it may be that the presence of the readily available energy of the molasses has filled the requirements of the animal and thus not necessitated the breaking up of more difficult protein compounds.

EFFECTS OF MOLASSES ON NITROGEN METABOLISM.

It is sometimes claimed that the excess of salts contained in molasses, and like foods, stimulate an extra secretion of urine and thus may bring about consumption and waste of nitrogenous compounds from the system. With an idea of seeing if there was any special indications in this direction, during the periods when the digestibility of the feeds were being determined, the urine was collected and the total nitrogen determined in it. The results obtained are set forth in tables 23 and 24, from a study of which it would seem that there may have been a slight increase in the quantity of urine secreted during the periods when molasses was being fed, but that the percentage of nitrogen usually decreased so as to allow about a constant per cent to be stored in the body. The figures show no special effect which could be attributed to the molasses.

TABLE XXIII.

Showing the quantity and the Nitrogen content of the Urine excreted during five days of Digestion Period.

Period	Steer No. 1		Steer No. 2		Steer No. 3		Steer No. 4	
	Quantity grams	Nitrogen %	Quantity grams	Nitrogen %	Quantity grams	Nitrogen %	Quantity grams	Nitrogen %
I.........	16850*	0.70	8800*	1.23	13390*	0.61	10140*	0.59
II........	31950*	1.29	17900*	1.61	34580*	0.95	39760*	0.85
III.......	42890*	1.29	32850	1.49	17600*	1.89	19950*	1.86
IV.......	41830*	1.44	28730*	1.19	33620*	1.50	28710*	1.53
V........	55400	1.35	55380	1.30	49810	1.10	53470	1.14
VI.......	23700	0.87	19370	0.99	....	....	....	....

*Some urine lost.

TABLE XXIV.

Showing the Nitrogen Metabolism during the different Digestion Periods.

Period	Steer No.	N-in Urine Grams	N-in Dung Grams	Total Excreted	Total Eaten	Total Stored	% Stored	% of Excreted N-in Urine
I Hay	1	106.58	157.5	264.1	306.4	42.3	13.78	40.37
	2	85.97	126.5	212.5	233.8	21.3	9.11	40.46
	3	74.20	175.7	249.9	371.6	121.7	32.75	29.69
	4	55.11	147.8	202.9	369.1	166.2	45.03	27.16
Average......	....	80.46	151.9	232.4	320.3	87.9	25.17	34.42
II Sucrene	1	352.27	400.0	752.3	1047.9	295.6	28.21	46.83
	2	283.44	343.5	726.9	921.1	194.2	21.08	38.99
	3	339.50	387.3	726.8	1085.5	358.7	33.04	46.71
	4	338.06	450.3	788.4	1125.2	336.8	29.93	42.89
Average......	....	328.32	395.3	748.6	1044.9	296.3	28.07	43.86
III Mixed Grain	1	550.56	532.7	1083.3	1243.2	159.9	12.86	50.82
	2	490.28	392.9	883.2	1230.5	347.3	28.22	55.52
	3	332.59	394.5	727.1	1231.0	503.9	40.94	45.75
	4	378.28	361.5	739.8	1243.0	503.2	40.48	51.14
Average......	....	437.93	420.4	858.4	1236.9	378.6	30.63	50.81
IV Mixed Grain and Molasses	1	595.58	406.5	1002.1	1325.6	323.5	24.41	59.43
	2	341.8	432.8	774.6	1327.5	552.9	43.12	42.69
	3	578.24	462.0	1040.2	1271.1	230.9	18.17	55.59
	4	432.69	383.0	815.7	1327.8	512.1	38.57	53.04
Average......	....	409.69	421.1	903.3	1313.0	409.7	31.07	52.69
V Mueller's Molasses Grains	1	745.16	383.6	1128.8	1130.2	1.4	.12	66.01
	2	715.09	553.0	1268.1	1139.0	none	none	56.38
	3	551.11	566.6	1117.7	1140.3	22.6	.20	49.31
	4	483.39	523.2	1006.6	1142.0	135.4	11.86	48.02
Average......	....	623.69	506.6	1130.3	1137.9	39.9	3.05	54.93
VI. Hay and Molasses	1	200.62	187.6	388.2	322.5	none	none	51.68
	2	186.79	207.0	393.8	318.8	none	none	47.43
Average......	....	193.71	197.3	391.0	320.7	none	none	49.56

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

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ALFALFA IN MARYLAND.

By C. W. Nash.

HISTORY OF ALFALFA.

Alfalfa has been used as a forage crop in Egypt, Greece and other Eastern countries for over 2,000 years. It is a native of Eastern Asia, where it thrives particularly well on the high dry plateaus. It was brought to Mexico by the Spaniards about four hundred years ago, and from there was taken to South America. It was introduced into the United States over a century ago from Central Europe, under the name of Lucerne, but was only locally grown until after its introduction into California from Chili, in 1854. From California it gradually worked its way Eastward, until now it is the chief forage crop in many of the Western States, and is being grown to some extent in nearly every State and Territory in the Union. No other forage crop is exciting so much attention at the present time.

ALFALFA IN MARYLAND.

Alfalfa was tried in Maryland over fifty years ago, and there are farmers who have been growing it for twenty to forty years, but its distribution has been only local until a few years ago, when the Maryland Agricultural Experiment Station, in cooperation with the United States Department of Agriculture, furnished seed to a large number of farmers to encourage them to try it experimentally, and to get data as to its adaptability to Maryland conditions. In the spring of 1902 question sheets were sent to each of these farmers for information as to the methods they had used in preparing the seed bed and seeding, and as to their success in growing alfalfa. The fall following a bulletin on "Alfalfa in Maryland" was issued by the Experiment Station.

Since 1902 several cooperative tests with farmers have been started, and many other farmers have tried alfalfa. Another list of questions was sent out in 1906, the object being to obtain information as to what character of soil and what methods of culture have given the best results in this State. While it was not possible to send a circular letter to every farmer growing alfalfa, and some of those to whom it was sent did not reply, the number of responses made was sufficient to fairly represent the average conditions in the State. There were two hundred ninety-two letters sent out, from which one hundred fifty-eight replies were received, thirty-six reporting failure, and one hundred twenty-two reporting the alfalfa doing well. The total acreage reported by these letters was about eight hundred acres. These one hundred twenty-two successful growers are located in every county of the State, except Wicomico and Caroline counties, and each of these two counties have in at least one instance in the past grown alfalfa successfully. The fact that the three counties having the largest acreage, namely, Baltimore, Talbot and Allegany, are in different sections of the State also shows that alfalfa is of general rather than sectional distribution.

The season of 1906 was exceptionally unfavorable for alfalfa. The drought in the early summer doubtless lessened the vitality of the plants, and the excessively long wet period in late summer practically kept, even those soils which were normally well drained, in a saturated condition. The effect was much more noticeable on the 1905 seedings than on the older fields, showing that alfalfa is not as hardy the first year as it is when older.

During the spring of 1907 a circular letter was sent to each of the one hundred twenty-two parties who had previously reported success with alfalfa, asking a reply as to the yield and number of crops obtained in 1906. The following table gives the dates of seeding, the yields per acre, and other data reported by alfalfa growers:

Names	County	Date Sown	No. of Acres	Yield per Acre	No. of Cuttings
				Tons	
John W. Llewellyn	Allegany	Apr. 1900	10	4½	3
M. R. Wilson	"	6 yrs. ago	7	2¼	3
M. R. Wilson	"	3 yrs. ago	5	3⅓	4
W. A. Combs	A. A. Co.	....	14	*	4
L. A. Palmer	" " "	....	5	2¼*	3
Harry Alder..................	Baltimore	Apr. 1900	2	5	......
Chas. A. Councilman	"	12 yrs. ago	66	5	4
T. V. Richardson	"	Apr. 1903	2	3½	3
Ephraim Haines...............	Carroll	Aug. 1904	1	7	4
Wm. Coulby..................	Charles	....	5	2½	2
E. W. Dawson.	Cecil	6 yrs. ago	⅝	*	......
T. J. Hackett................	Dorchester	....	4	4½	3
R. R. Lewis..................	Frederick	....	18	3½	3
John Schafer	"	May 1903	1	*	4
H. P. Weber..................	Garrett	May 1902	1	3	2
Dr. Herbert Hoopes..........	Harford	....	4	3	3
Wm. Mikel....................	"	....	6½	3½	3
Earnest N. Adams............	Howard	....	18	3	3
Abram S. Crawford	Kent	....	2	4½	4
Samuel L. Wright............	"	June 1902	2½	*	......
C. C. Mainhart	Montgomery	Aug. 1905	3	3	3
Dr. A. Stabler................	"	....	6	3	3
E. P. Thomas	"	Aug. 1905	3	3½	3
John Dicus...................	Prince George	Aug. 1905	1	3	2
Jas. T. Anthony..............	Queen Anne	....	4	3¼	4
D. E. C. W. Thom............	" "	....	3	3¾	4
C. B. Greenwell..............	Saint Mary's	....	3	3⅓	4
A. Hyatt.....................	" "	May 1903	1	5	5
A. Hyatt.....................	" "	Aug. 1905	2	6	6
Jos. M. Mattingly............	" "	Apr. 1904	4½	4½*	4
Wm. S. Richardson	Somerset	....	8	6½	4
A. Sudler	"	....	1½	4	4
John Aikenhead..............	Talbot	....	1	5½	3
Miss Julia Dixon	"	Aug. 1905	1	6	5
Chas. E. Fairbanks	"	....	8	4	3
Geo. B. Taylor	"	....	4	4¼	4
Jno. S. Rohrer	Washington	....	1	4½	3
I. T. Costen..................	Worcester	....	1	3¼	4
F. E. Matthews	"	....	1	5*	......

The above yield reported by Mr. Ephraim Haines, Medford, Maryland, shows what may be accomplished under favorable conditions, his four cuttings in 1906 making a total measurement of twelve feet, and a total yield which was estimated at seven tons per acre.

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*Mr. W. A. Combs reports four good cuttings a year.

*Mr. L. A. Palmer, three tons per acre in 1905, and two and one-fourth tons in 1906.

*Mr. E. W. Dawson, five or six tons per acre for six years.

*Mr. John Schafer, five tons per acre in 1905.

*Mr. Samuel L. Wright, five tons per acre in 1903-04-05.

*Mr. Joseph M. Mattingly, five and one-third tons per acre in 1905, and four and one-half tons in 1906.

*Mr. F. E. Matthews, five tons per acre in 1906, and five to seven tons per acre each year previous.

Rev. P. P. Arnd, Elkton, Maryland, reports that his first cutting in 1905 attained a height of five feet, and yielded one ton of hay from one-eighth acre of land, and produced sufficient hay and green forage during the season to keep a cow in a very heavy flow of milk from May to December, seven months, with no other feed except three hundred to four hundred pounds of ground grain, mostly bran and corn. Estimating the amount of hay required to keep a cow seven months at two tons, a yield of hay at the rate of sixteen tons per acre was obtained.

Some of the experiences of Maryland farmers show that alfalfa may remain a profitable crop for several years without reseeding. Mr. J. T. Davis, Federalsburg, Maryland, had a field of one-half acre, sown in 1895, which made an average of about four cuttings a year until 1905, when it was plowed up. Mr. John Llewellyn, Cumberland, Maryland, has a field of ten acres, sown in 1900, which seems to be getting better every year, and last year made a yield of four and one-half tons per acre. Hon. Charles A. Councilman has a field of sixty-six acres, sown twelve years ago, which made four or five tons per acre last year. Other fields mentioned in the preceding table also show the longevity of alfalfa in this State.

SOILS FOR ALFALFA.

Alfalfa may be successfully grown on a great variety of soils, but is much more easily grown on certain types of soil than others. The best soil is one with a surface sufficiently heavy to retain an abundance of moisture, and furnish a good storehouse for plant food, and with a fairly deep sub-soil sufficiently porous to allow good under-drainage. The soil survey types of Maryland possessing these characteristics in the largest degree are the Sassafras loam, the Sassafras sandy loam, the Cecil loam and the Cecil mica loam.

The Sassafras loam occurs in large areas on the Eastern Shore of Maryland, and in small, much-scattered areas on the Western Shore, and in Southern Maryland. It is a brown loam to a depth of eight to ten inches, underlaid by a yellow clay to a depth of three to thirty feet, below which is a layer of sand or gravel a foot or more in thickness, which gives good under-drainage if it lies sufficiently near the surface. The Sassafras sandy loam closely resembles the Sassafras loam, except that it contains more sand, and is a lighter and better drained soil.

The Cecil loam and the Cecil mica loam occur in large areas in the Piedmont Plateau. They are made of disintegrated rock, and are sufficiently loose to allow good drainage, yet, sufficiently compact to retain a fair amount of moisture and hold plant food in store. They are brown-colored loams at the surface, beneath which is a deep layer of slightly lighter colored loam. The Cecil mica loam, as its

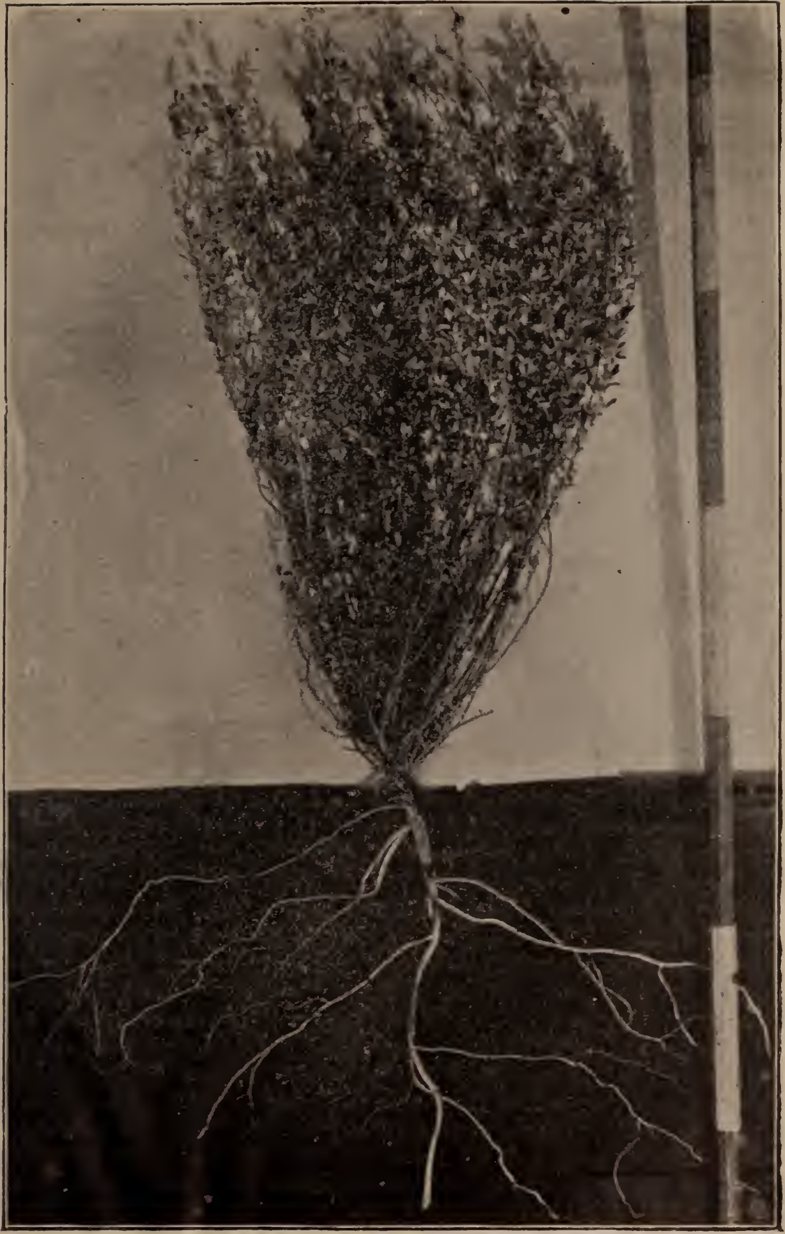

Plate I—A Vigorous Two-Year Old Alfalfa Plant.

name implies, contains a larger amount of mica. It is not so abundant as the Cecil loam.

Limestone soils are usually well suited to the growing of alfalfa. These are clay soils, underlaid with limestone rock at varying depths, and occur in considerable areas in Baltimore, Carroll, Frederick and Washington Counties. This portion of the State has a much higher elevation, and a much lighter rainfall, than Eastern and Southern Maryland, and appears to be in every way suited to the production of alfalfa. Two precautions, however, should be taken in choosing a field for alfalfa on the limestone soils; the rock must lie several feet (preferably four or more) below the surface, to give ample room for the deep-growing alfalfa roots to develop, and the soil must be well drained, preferably well drained at the surface by the slope of the land, and well under-drained through layers of sand or gravel, or other porous strata.

The general classes of soils which have the best physical condition naturally are the sandy, medium and clay loams. The loamy sands and the medium heavy clays, however, may be made suitable for alfalfa growing by manuring and drainage. The light sandy and the very heavy clay soils are least adapted to growing alfalfa. On sandy soils well stocked with humus the growth has been vigorous when moisture has been abundant, but during droughts the alfalfa has suffered severely, and during the winter it has been thrown out by the heaving or the alternate freezing and thawing of the soil. On some sandy soils sown in the fall of 1906 the crop was entirely destroyed by the plants being heaved out. On heavy clay soils in good tilth alfalfa has thrived well under moderate rainfall, but during the excessive wet periods it has been "drowned out," and during the winter it has been thrown out by heaving. The soils least affected by heaving are those composed of soil particles of moderate size, and containing a large amount of humus. The danger from heaving is much greater the first winter after seeding than later, after the plants have become deeply rooted.

Alfalfa does best on well-drained soils where the water level is several feet below the surface. Alfalfa is a very deep-rooted plant, sending its roots down into sub-soil which is largely unavailable to other farm crops. These roots will not thrive in a water-soaked soil, and in attempting to grow alfalfa on a wet soil, or a soil with the water level only a few feet from the surface, the alfalfa is placed in unnatural conditions, and little can be expected of it. If possible, a field with a sufficient slope to effect thorough surface drainage, and sufficiently open or porous to provide good under-drainage, should be selected for alfalfa. Strata of sand or gravel a few feet below the surface usually make a very effective drain. Soils which are not well drained may often be made suitable for alfalfa growing by the use of open ditches or by tile drainage.

ALFALFA IN ROTATION OF CROPS.

The best crops to precede alfalfa are those that leave the land unusually free from weeds and weed seeds, and those that add organic matter, and thus enrich the soil. Corn and potatoes are good for the first purpose, and crimson clover and cow-peas for the second. On land rich in organic matter the cow-peas or crimson clover may be cut for hay, but on lands very deficient in humus, it may be more profitable to plow under the whole growth. Potatoes are very good for getting the land in condition, and several farmers in this State have been the most successful when they have sown alfalfa after early potatoes. Land that is used for trucking, if not too light, usually does well, because such land has been prepared by manuring and cultivation. Alfalfa should not follow directly after a sod, as grasses usually run the alfalfa out within two or three years. A crop of corn grown between a sod and alfalfa will give time for the sod to decompose, and will destroy most of the grass. Where sweet corn is grown for canning purposes, and the crop removed as early as possible, it may be followed by alfalfa, and when the land is rich in vegetable matter alfalfa may be sown in the fall, after wheat, if special preparation of the land is made. In preparing for alfalfa the rotation should be planned ahead for two or more years, as mentioned below under "Soil Enrichment."

SOIL ENRICHMENT.

One of the principal causes of failure of alfalfa in Maryland has been a lack of sufficient organic matter in the soil. The continuous cropping with tobacco, or one or two of the grain crops, has more or less exhausted the humus or organic matter, and has thus affected its supply of plant food, its physical condition, and its capacity for holding moisture. It is necessary on these humus-exhausted soils, if one would have success with alfalfa, to replace the plant food removed by continuous cropping, by the application of barnyard manure, by the use of green manure crops, or by the rotation of crops in which legumes, such as cow-peas, vetch and clover are used. The quickest way to increase the organic content of the soil, and improve its physical condition, when plenty of manure is not available, is by use of green manure crops. The legumes best adapted to this purpose are cow-peas, vetch and crimson clover. Other crops which may be used for green manuring are wheat, rye and sorghum. These crops may be grown one after the other, or grown in rotation with other crops, as shown in rotation plans in the following paragraph.

A good rotation, when a few years can be allowed to fit a field for alfalfa, is as follows:

First year—Corn, followed by crimson clover.

Second year—Crimson clover, followed by cow-peas, and seeded to wheat in fall.

Third year—Wheat, followed by cow-peas or vetch.

Fourth year—Corn, followed by crimson clover.

Fifth year—Crimson clover, followed by alfalfa.

The crimson clover may be sown in the corn field after the last cultivation, and should be ready to cut in May of the following season, in time to grow a crop of New Era cow-peas, which should be cut early enough to allow the seeding of wheat in the fall. By this rotation, even by using the cow-peas for hay, the land will continually become richer, and at the same time will usually be bringing in better returns than it would by continuous grain farming. If both the cow-peas and crimson clover are turned under, the land should become rich enough in organic matter at the end of the rotation, even without manure to produce good crops of alfalfa. This system is one that may be used to advantage when manure is not available, and when large fields are being fitted for alfalfa seeding. When manure is plentiful, the following preparation will be sufficient: Corn followed by crimson clover the first year, with the crimson clover plowed under the next spring, and the ground summer fallowed, and alfalfa sown in the fall, or crimson clover cut for hay and a heavy coat of manure plowed under in its place. When plowing for the corn a heavy coat of manure should be turned under. Land that is in wheat may be fitted for alfalfa quickly by sowing cow-peas after the wheat, and by plowing them under in late fall, or by sowing crimson clover, and plowing it under the next spring, then seeding cow-peas which may be cut for hay, manure preferably having been plowed under for both the fall and spring crops. The manure should be applied to the crops preceding the alfalfa, so that there will be sufficient time to improve the physical condition of the soil, and to kill the weeds introduced by the manure; however, if the manure is well rotted, so that it is free from weed seed an application of manure is beneficial even at seeding time.

The value of manure in growing alfalfa has been well demonstrated on the farm of Mr. Henry Fuss, of Union Bridge, Carroll County, who seeded two acres of alfalfa in the fall of 1905. A load or two of well-rotted manure from the hog lot was spread on one corner of the field before sowing the alfalfa, and in the spring of 1907 there was a perfect stand of rank-growing alfalfa where the manure was applied, while around it the alfalfa had been mostly killed, and was much smaller.

The value of manure is shown on other farms. There are several growers in the State who have two or more fields of alfalfa, one field having been manured, and having plenty of humus and nitrogen, and others which have not been manured, and have been continuously cropped without a legume in the rotation, who have a permanent stand on the manured field, while the unmanured fields have never produced much, and at the end of a year or two were practically worthless. Farmers who are using large amounts of barnyard and green manures are raising large crops of alfalfa, while others in the same locality, and under similar soil conditions, but who are not using anything but commercial fertilizers are unable to grow alfalfa with any success. One illustration of such a condition may be found in Baltimore County, around Glyndon, where Mr. Councilman has been growing alfalfa successfully for years, and has a sixty-six acre field that is twelve years old, and yet so far as known to the writer, or Mr. Councilman, no one else has grown the crop successfully within several miles of Mr. Councilman's farm, although many have tried raising it.

Commercial fertilizers are of value in that they supply available plant food, but they will not take the place of manure because they do not add vegetable matter to form humus, and to improve the physical condition of the soil. Their chief value is in conjunction with manure to furnish the mineral elements, phosphorous and potassium, and to furnish a greater abundance of plant food for the alfalfa while young and tender. It can doubtless be used with profit at time of seeding for these reasons.

LIMING.

Alfalfa reaches its highest development on neutral or slightly alkaline soils. In acid soils it usually has a sickly, yellow appearance, and does not make a vigorous growth, doubtless due to the fact that the acid conditions are not suited to the development of the alfalfa bacteria.

The acidity or alkalinity of the soil may be tested by the use of blue litmus paper, which can be secured of any druggist. The litmus test may be made by moistening a portion of the soil so that it will stick together, and inserting the litmus paper in a cut made with a knife, and closing the soil together compactly around the paper. If within a half hour or less the litmus paper turns pink the need of lime is indicated. Where tests are not made, and the soil has not been limed for years, it is much safer to lime than to run the risk of the alfalfa being killed out by the acidity of the soil. The amount that should be applied varies with different soils, clay soils requiring a heavier application than sandy soils. On clay soils which have not been limed in many years about one ton per acre should be applied, while soils in which the acidity has been partially corrected should receive a proportionate amount. On sandy or humus exhausted soils it is not advisable to put on more than one thousand pounds at one time, for lime is an indirect fertilizer, and liberates plant food by hastening the decomposition of the organic matter in the soil, and thus reduces its fertility. Clay soils are more retentive of plant food, so that less is lost by this decomposition, and, furthermore, the clay soils are improved greatly in texture by the flocculation of the soil, or the aggregation of the smaller particles into larger ones.

Oyster shell lime or stone lime is generally used, though other substances, such as marl, may be used more economically, where they can be obtained on the farm for the expense of digging. The lime should be applied on the surface, and worked in with the surface soil, and it should be put on in as active a condition as possible. To do this the lime should be slaked with water, and as soon as slaked should be spread as evenly as possible. It may be applied with a shovel, or with the lime attachment which comes with most manure spreaders.

Ground stone lime, which has recently been put on the market, is a finely ground lime, which is easily distributed, and is thought to be better than the burnt lime, as it can be applied in the active state. It can be applied through the fertilizer attachment of the ordinary grain drill.

INOCULATION.

Like other legumes, alfalfa has the ability in the presence of certain microscopic organisms, called bacteria, to obtain nitrogen from the air in the soil. When, however, the bacteria are absent, alfalfa has to depend for its supply upon that already in the soil, and is not able to make a vigorous growth, except when the soil is rich and well supplied with nitrogen, and is not able to build up the nitrogen content of the soil, the great function of leguminous plants.

It is somewhat difficult to determine whether the alfalfa bacteria are present in a field or not before growing alfalfa, but unless the field has previously grown alfalfa, or unless sweet clover has grown on the field, there is little chance of the soil containing the bacteria, and it is advisable to inoculate the soil.

Sometimes a partial inoculation has been secured through bacteria which have been carried upon the seed, but this means of inoculation is uncertain, and not thorough, and should never be depended upon.

Soils may be inoculated artificially in three ways: By inoculated soil; by water extract from inoculated soil, and by the use of artificial cultures of alfalfa bacteria. Inoculation by means of inoculated soil has given much better success than other methods. The soil should be taken from a field known to be well inoculated, and from a place in the field which is as free as possible from harmful weed seeds. The surface soil may be taken to the ordinary depth of plowing, and should be kept in a moist condition, and be kept from the sunlight until it is applied. The soil may be applied with the fertilizer attachment of a grain drill, or if no drill is available, may be sown by hand, and immediately harrowed in. When applied by hand one-half of the soil should be sown one way, and one-half crosswise, in order that no spots may be missed. The inoculated soil should be applied at the rate of four hundred to five hundred pounds per acre, and if plenty of soil may be had conveniently a heavier application may be made. If the inoculated soil must be shipped by boat or rail at great expense, and is known to be well inoculated, it may be applied in smaller quantities, even as low as one hundred fifty to two hundred pounds per acre, with a fair chance of securing inoculation, which, if not perfect at first, will become so within one or two years. In many sections of the State *melilotus alba,* or sweet clover (in some localities called gala gumbar) grows commonly along roadsides and in waste places, and the soil from such spots may

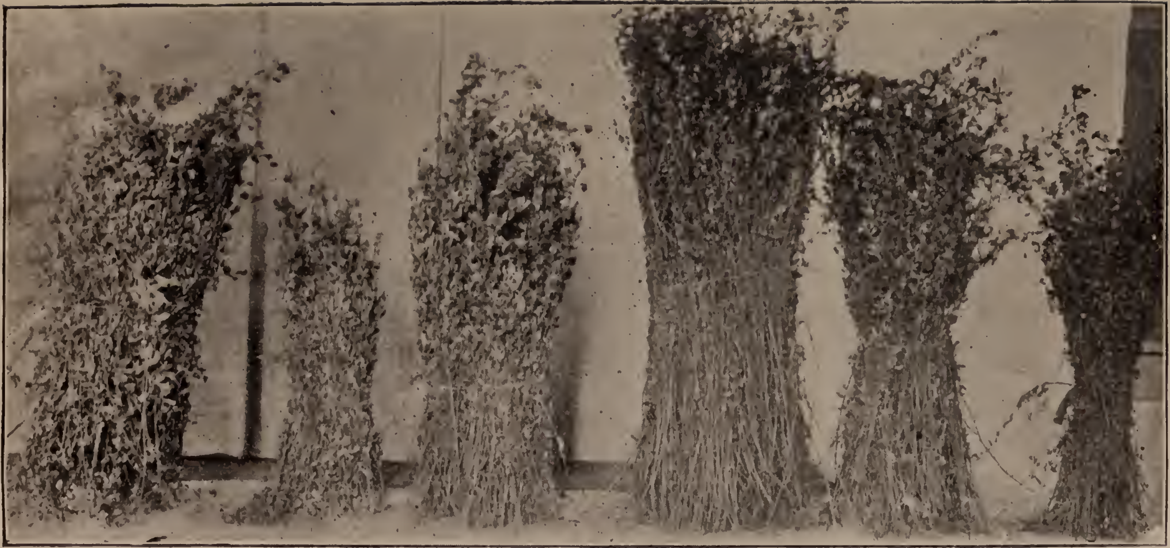

Plate II—Showing Results of Inoculation Experiment.

Plot 1—Inoculated with Alfalfa Soil—Yield 1.50 lbs.
Plot 2—No Inoculation—Yield 0.50 lbs.
Plot 3—Inoculated with Sweet Clover Soil from College Farm—Yield 1.40 lbs.
Plot 4—Inoculated with Sweet Clover Soil from Anne Arundel Co.—Yield 3.15 lbs.
Plot 5—No Inoculation, but Planted in Rows and Cultivated.

Bundle 1—One-half of Plot which showed evidence of Inoculation washed over from Plot 4—Yield 1.05 lbs.

Bundle 2—Other half of Plot 5—Yield .45 lbs.

be used for inoculation, if the alfalfa soil cannot be had near at hand. An experiment conducted by Prof. W. T. L. Taliaferro, formerly Agronomist of the Experiment Station, shows that the sweet clover soil produces as good inoculation as the alfalfa soil (See plate No. II.).

The inoculation by water extract includes the passing of water through an inoculated soil, and using this to inoculate the alfalfa seed, which should be dried out of the sunlight. This method is unsatisfactory in many ways, and is not to be recommended.

The inoculation by means of artificial cultures has usually proved unsuccessful, and until better preparations have been developed and thoroughly tested it is not advisable to use this method.

Every alfalfa grower should know how to determine whether or not his alfalfa is well inoculated. Many farmers in this State who have been growing alfalfa for years say they have never seen a tubercle, though they have looked for them several times. The reason in some cases, doubtless, was because there were no tubercles, but in other cases it evidently was not known what the tubercles were like, or proper methods were not used to find them. Tubercles occur as wart-like growths on the roots, most of them being about the size of a pin head, but sometimes growing in clusters which may be as large as a pea. They are much easier to find on young plants, as they are then nearer the surface, and nearer the main root. They are often noticeable by the time the plants are three or four inches high, and should be very abundant and conspicuous by the time the plants are six or eight inches high. Plate No. III shows some small plants with tubercles on their roots. On older plants the tubercles are more scattered, and are harder to find. However, they can be found by removing a plant with considerable soil attached, and carefully removing the same with the hands, or, better, by means of running water, so as not to break off the small roots where most of the tubercles will be found. When plants a year or more old are pulled up what tubercles they had have usually been left in the soil.

When only a part of the plants have tubercles, by the time the alfalfa is six or eight inches high the inoculation is not what it should be. Fields on which inoculation has been unsuccessful may be inoculated with earth after the first cutting, and the land harrowed with a disc, or spiked-tooth harrow, but inoculation at this time is not so effective as when done at or before seeding time.

PREPARATION OF SEED-BED.

The importance of a good seed-bed cannot be too strongly emphasized, for alfalfa plants are delicate while young, and are very sensitive to unfavorable conditions, such as weeds and lack of moisture. The soil should be fine and loose for the surface two or three inches, and below that should be sufficiently firm to favor capillary action, yet porous enough for good drainage and aeration. On deep, medium or heavy soils the deeper the soil has been plowed the better, and when

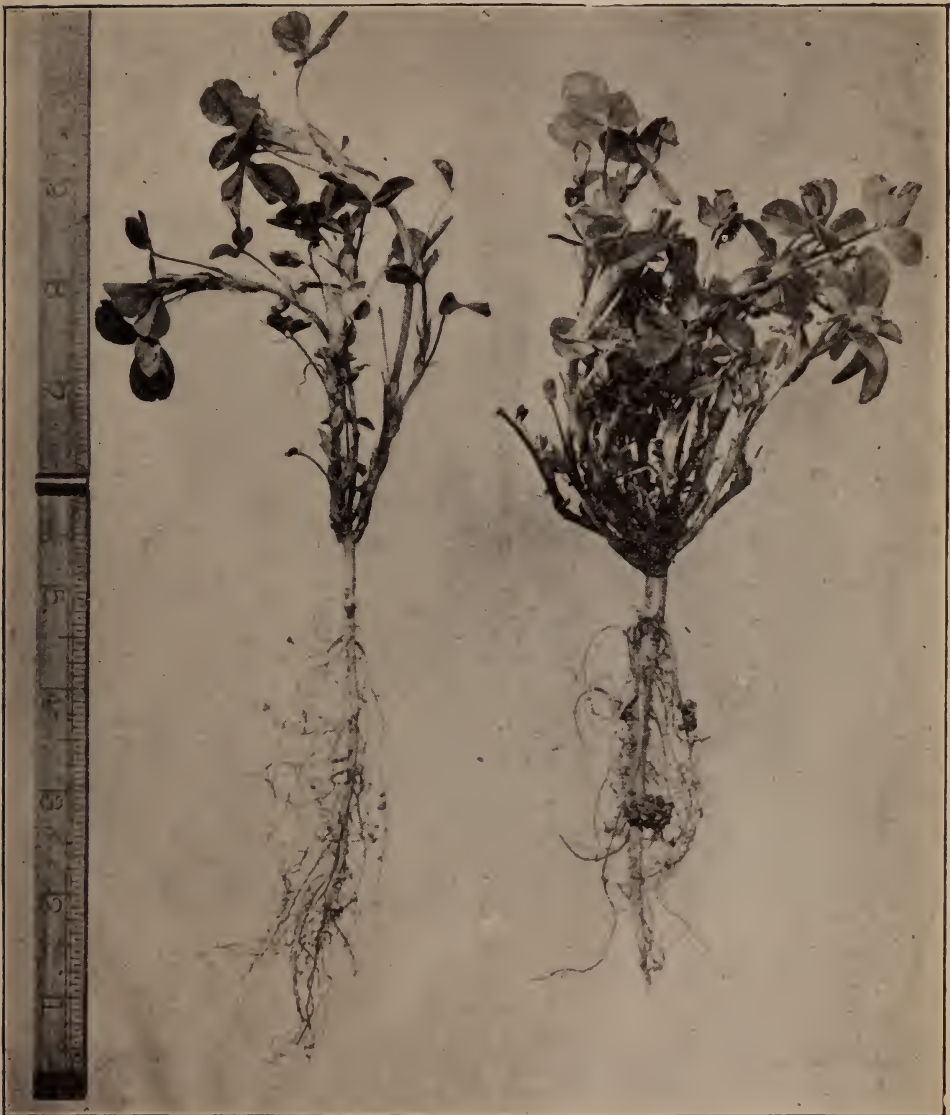

Plate III—Showing Young Alfalfa Plants with Tubercles on Roots.

preparation begins two or three years previous to seeding, the depth of plowing should be gradually increased to eight to ten inches. The proper firmness of the seed-bed is secured when land is plowed from two to six months before seeding time, and only the surface is kept stirred.

The method of preparing the seed-bed will necessarily depend upon the previous cropping and treatment, and upon the length of time which there is to prepare the ground. Sometimes it is not possible to wait long enough for heavy rains to settle the ground without delaying the seeding too long. One of the best ways to prepare the seed-bed is by repeated harrowing with a spiked-tooth harrow, the tramping of the horse's feet, and the weight of the harrow, with teeth set slanting, serving to pack the soil. The value of thus packing the soil was shown in some fields seeded last fall, the edges and corners which were compacted by the horses turning around being much more vigorous and thickly set than the other portions of the field. This was especially noticeable on fields which had no heavy rains to compact

Plate IV—Growth of Alfalfa on inoculated portion of a field sown by Mr. W. Beall, Beltsville, Md., in September, 1905. Picture taken in spring of 1906, when plants were about fifteen inches high.

them, and which had not been plowed very long before seeding. Different ways of preparing the seed-bed after different crops, such as crimson clover, potatoes and wheat, will be considered in the following paragraphs.

A field in crimson clover may be prepared for seeding alfalfa in either of two ways: Plow the crimson clover under as green manure, or cut for hay when in full bloom, and summer fallow until sown to alfalfa; or plow the crimson clover under about May 15, and sow to an early cow-pea, such as the New Era, which should be cut for hay in time to allow two or three weeks to prepare a suitable soil mulch, and to kill most of the weeds before time to seed the alfalfa. When plowing under the crimson clover the plowing should be as deep as possible, so as to loosen up the soil to a greater depth, and then in the fall all that is necessary to do is to get a fine mellow surface of about three inches, free of weeds, the sub-surface being of about the right compactness.

Plate V—Growth of Alfalfa on uninoculated portion of Mr. W. Beall's fileld. Taken on the same date as Plate IV.

If alfalfa is to follow potatoes, or some other truck crop, and the field is rich, clean and mellow, the potato vines, or other refuse, should be raked off, and the seed-bed prepared by the use of a disc harrow and other surface-working implements. If the field is weedy it should be plowed shallow, or to a depth of about five inches.

Wheat or other small grain when on rich land, previously well cultivated, may be followed by alfalfa if the preparation begins soon enough after harvest. The land after wheat has been removed is usually mellow and somewhat moist, and if the surface is worked up soon will be in good condition but if left for some time will become dry and baked. Early plowing as compared with late plowing will leave the soil more free from clods and will give more time for the compacting of the soil and for the killing of weeds. To kill the weeds and to keep the soil mellow on top so as to conserve the moisture, the harrow should be used every week or after every rain until the field is seeded. If manure is applied at this time it should be a light coat of well rotted manure.

SEEDING ALFALFA.

It is usually conceded that the best time to seed alfalfa is in late summer or early fall. If the field has been summer fallowed it should usually be seeded early in August, but when alfalfa is sown after cowpeas, wheat, or other full season crops, it is usually best to seed in the middle or latter part of August. It should not be seeded until the proper seed-bed has been secured, even if it is necessary to wait until late in August. Seeding after September 1 will not make as vigorous a growth during the fall as the earlier seeding and is more apt to be winter killed. The late summer seeding is preferred to the spring seeding mainly because the alfalfa is able to get well established in the soil during the fall when the weeds are comparatively inactive, and then is able to make a vigorous growth in the spring and keep ahead of the weeds.

Spring seeding may be successful on fertile land which is especially free from weed seeds, and when practiced should be seeded as early as a suitable seed-bed can be prepared. Fall plowed land or land devoted to a cultivated crop the previous season offers the best opportunity of preparing the proper seed-bed. Better results have usually been secured by growing alfalfa without a nurse crop, but some farmers are using this method with good results, especially with spring seeding. A thin seeding of barley is one of the best crops for this purpose. The nurse crop should never be allowed to reach maturity, but should be cut for hay, or, at such frequent intervals that it will not provide dense shade for the alfalfa.

Alfalfa seed should be secured from some reliable firm under guarantee of purity and vitality, and then should be examined for impurities and tested for germination. To give time for this testing the seed should be secured early and in the germination test the seed should test not less than eighty or eighty-five per cent, and better not less than ninety or ninety-five per cent. Every farmer may test the vitality of his own seed. A simple method of testing is to lay in the bottom of a plate two thicknesses of blotting paper or several thicknesses of newspaper, wet thoroughly, and on this place one hundred average seed. These are covered with a layer of wet paper and an inverted plate is put on top of the first plate to prevent drying out from evaporation. The germination should take place in four to six days.

Adulterants are often found in alfalfa seed, some of the most objectionable weed seeds being those of dodder, yellow trefoil and narrow-leaved plantain. If a farmer does not feel confident to judge the grade of alfalfa seed offered him by dealers he may have the purity and viability determined free of cost by the Experiment Station, if he will send a sample of the seed for that purpose. Address: Maryland Agricultural Experiment Station, College Park, Maryland.

Another important thing to consider in buying seed is its source. Variety tests made with European and Asiatic varieties as compared with seed from different parts of the United States show that the foreign seed is less hardy and often less viable than the American-grown seed, and that the seed obtained from the Northern part of the United States is more hardy than that from farther South.

The amount of seed to sow depends upon the quality of the seed and upon the preparation of the seed-bed. If the land is well prepared, and the seed good twelve to fifteen pounds per acre is as satisfactory as a larger amount, for if the seed all grew there would be from sixty-five to eighty plants per square foot, which is many more than will stand after the first season. However, much of the seed on the market is of low vitality and if only about seventy-five per cent. of the seed sown will germinate it should be seeded at not less than twenty pounds per acre. Seed of still lower vitality should be applied at a correspondingly heavier rate.

The seed may be sown with a broadcast seeder, by hand, or may be drilled in, but whatever the method, extreme care should be exercised to distribute the seed evenly and not to cover it too deeply. One objection to using the drill is that the seed is usually put in too deep and comes up poorly. The wheelbarrow grass seeder is one of the best implements for this purpose.

The seed should be covered very lightly, one-half inch to three-fourth inch being sufficient. The best method of covering is by means of the weeder run over once or twice after seeding, or by means of one harrowing with a light spike-tooth harrow with the teeth set shallow. One field sown to alfalfa last fall, under favorable conditions otherwise, but harrowed once each way with the harrow teeth set perpendicular, was covered so deeply that some of the plants were just coming up two months after sowing and the only plants strong enough to survive the winter were those from seed which chanced to be near the surface and were four or five inches high at the beginning of winter.

CARE AFTER SEEDING.

The first season after seeding, alfalfa may become so badly infested with weeds that there is danger of its being crowded out, or it may turn yellow and make a stunted growth from attack of leaf spot or other fungus diseases, or because of insufficient inoculation or improper soil conditions. In either case, or whenever alfalfa discontinues making a healthy growth, the best treatment is to clip with the mower as high as the mower will cut, or about three and one-half inches. It is not advisable to clip alfalfa when it is not weedy and is growing well.

The right time to cut alfalfa for hay is when it is about one-tenth in bloom and before the young shoots which make the next crop, have made a sufficient growth to be cut off by the mower. The vitality of alfalfa is very much lessened by allowing it to stand very long after the proper time for cutting, and it is not advisable to delay cutting later than full bloom, even at risk of losing the crop. After the first cutting alfalfa can usually be cut every four to six weeks, but it should not be cut so late in the season but that a few inches of growth are left for winter protection.

Alfalfa responds very favorably to applications of manure or of mineral plant food. It may be top-dressed during the fall or winter, or immediately after any of the cuttings. If applied soon after seeding the manure should be especially free of weed seeds. After the alfalfa has become established in the soil any manure which is not too coarse may be applied, but care should be taken that it is spread evenly and not so thickly as to smother the alfalfa.

Alfalfa should not be pastured the first year after seeding, but in old fields, if not pastured too heavily, and if the stock are kept off when the field is wet and are taken off in the fall in time for a winter cover to form, pasturing will not be especially harmful.

One of the best treatments for stimulating a healthy vigorous growth in old alfalfa fields is to make a deep mulch with a disc harrow. Fields after they are a year old, and have become weedy or are growing slowly, may be helped by a thorough discing, and there are instances in which three or four-year-old fields have begun to fail, which, after discing, produced as well as ever for two or three years longer. It is advisable to disc alfalfa at least once each season after it is a year old, the discing being done in the spring or after the first or second cuttings. The discs should be sharp and should be heavily weighted, so that it can be made to cut deeply without setting the two parts of the disc at a sharp angle.

Alfalfa is often a fair stand except in rather small spots. In such cases the spots should be disced and reseeded rather than leave a poor stand or plow up the whole field and reseed.

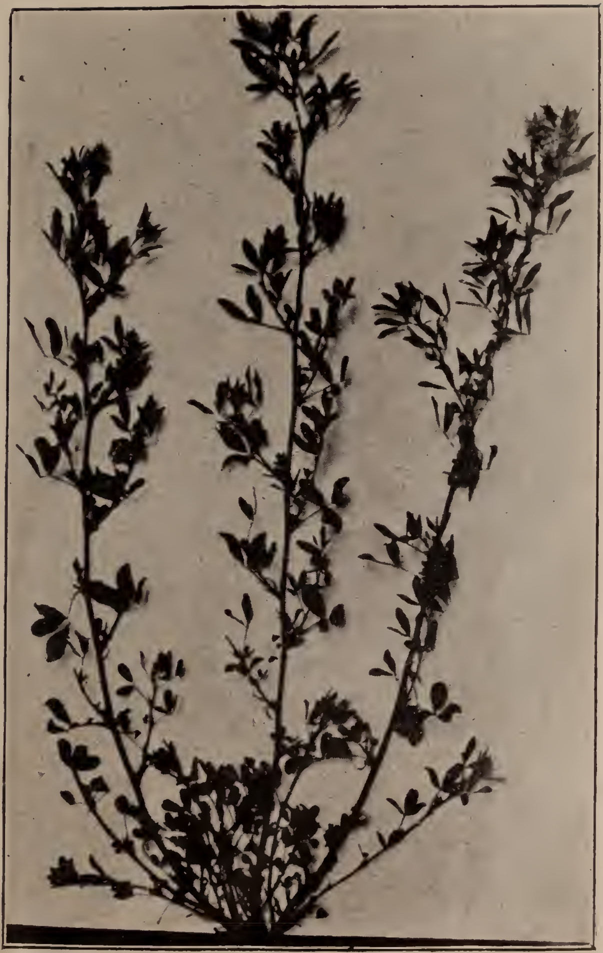

Plate VI—Showing size of new growth when Alfalfa is left to nearly full bloom.

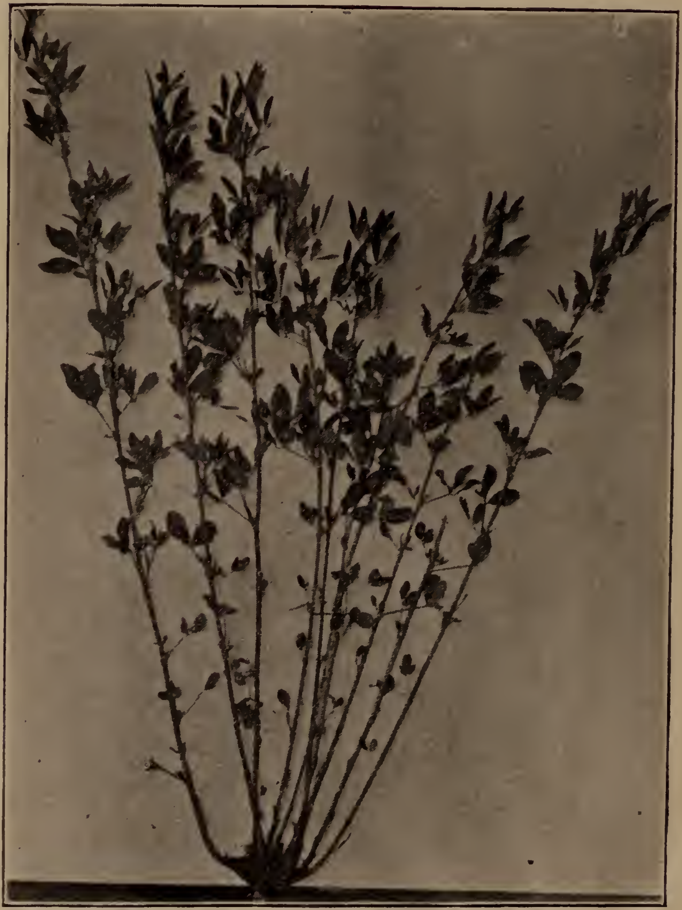

Plate VII—Showing the new growth barely starting when plant is just ready to bloom.

MAKING ALFALFA HAY.

The best alfalfa hay is made by raking and cocking while fairly green and allowing to cure for several days in the cock. On account of the uncertainty of the weather, however, this method is often found impracticable and a quicker method in which the alfalfa is dried in the sunlight must be used. It is always very important that the raking and as much of the other handling of the crop as possible be done while the alfalfa is sufficiently green to retain its leaves, as the leaves are by far the best part of the plant.

A method of handling the crop which has given good satisfaction at the Experiment Station is to cut the alfalfa in the morning as soon as the dew is off, allow it to remain in the swath as late in the afternoon as possible and yet get it raked before the evening dews fall and then put it in tall cocks, if it looks like rain; otherwise leave it in the windrow over night. If the next day is sunshiny the hay is scattered after the dew is off, allowed to dry until late afternoon and put in the barn. If the weather is not favorable for drying, more than two days will be required to cure the hay.

Hay put in the barn or stack when only partially cured is likely to mould or to char and be dusty so that it is practically unsalable, and in some cases sufficient heat is generated to ignite the whole mass.

SUMMARY OF REPORTS FROM ALFALFA GROWERS IN MARYLAND.

In the tabular data below the one hundred twenty two parties who reported that they had good stands of alfalfa at the time of making their reports are classed as successful, though some had grown it only one year, while the thirty-six parties who had tried growing alfalfa, but reported failure, are classed as unsuccessful.

Table showing the Number and Per Cent. of Successful and Unsuccessful Growers in Relation to Certain Treatments.

Treatment of Crop	Successful Parties		Unsuccessful Parties	
	No.	Per Cent.	No.	Per Cent.
Using Manure..............	91	74.6	15	41.7
“ Lime	66	54.1	10	27 8
“ Com. Fertilizer	57	46 7	15	41.7
“ Com. Fert. and Lime.	39	32.0	7	19.7
“ Manure and Lime....	52	42.6	7	19.7
“ Manure and Lime and Com. Fertilizer.....	33	27.0	6	16.7
“ Nurse Crop..........	7	5.7	2	5 6
“ Inoculated Soil.......	41	33 6	7	19.7
Seeding in Fall.............	82	72.1	13	36.1

While some seedings reported as failures received good treatment and some successful ones poor treatment the table shows that there is a very much larger percentage of the one hundred twenty-two successful growers who practiced certain good treatments, than there is of the thirty-six unsuccessful parties. This is shown by comparison of the third and fifth columns which show that the per cent. of instances in which manure, lime and inoculation were used is about twice as great among the successful farmers as among the unsuccessful.

Manure was used by ninety-one of the one hundred twenty-two successful growers or three-fourths of them, and by less than forty-two per cent. of the thirty-six unsuccessful growers, showing that manuring and success with alfalfa are closely associated.

Lime was used by fifty-four per cent. of the successful parties and by less than twenty-eight of the unsuccessful. None reported any damage from its use, a few reported no benefit and a great many reported very favorably of its value. Doubtless some of those who have not reported using lime had used it on some previous crops. Lime was used at the rate of eight to one hundred bushels per acre, and those who had tried different amounts thought twenty to twenty-five bushels a sufficiently heavy application at one time.

Inoculation was practiced by over twice as large a per cent. (forty-one per cent.) among the successful parties as by the unsuccessful. In this connection it must be remembered that many of the uninoculated successful fields will not be permanent successes, and that there are conditions under which the uninoculated fields may have become inoculated, naturally. These are as follows:

First—Some of the fields may have been so rich and so well prepared that the plants were kept growing vigorously until the few bacteria introduced by the seed or that chanced to be in the soil had time to develop and become sufficiently numerous to inoculate the field.

Second—On many of the fields previous attempts to raise alfalfa had been made so that on the plants which survived sufficient bacteria may have developed to have thoroughly inoculated the soil.

Third—Many of the fields were naturally supplied with bacteria because of sweet clover having grown in the field or on its borders.

Those who have tried inoculation with soil are most heartily in favor of its use.

Fall seeding was practiced by about three-fourths of the successful parties, many of whom had tried both spring and fall seeding and have found fall seeding preferable.

EXPERIENCE OF ALFALFA GROWERS.

Hon. Chas. A. Councilman has been growing alfalfa since 1886 and at the present time has over one hundred acres, sixty-six acres of which were seeded twelve years ago. This old field will average only about a half a stand but when seen by the writer on May 16, was pasturing three hundred fifty hogs, and promised a fair cutting of hay. He seeded a twenty-one acre field to alfalfa in the spring of 1907 which came up very evenly and is looking well. This field, he says, was sown in alfalfa fifteen years ago and the alfalfa plowed up three years ago, since when he has been preparing it for raising the best alfalfa he has ever grown. His method has been as follows: Each of the three years he sowed corn and cow-peas and cut for ensilage, then a heavy coat of manure, about forty loads per acre, was applied and plowed under, the first two years the manure being plowed under in the spring and the last year (1906) the plowing being done in the fall in order to give a more compact seed bed. This spring he worked up the surface with disc and spike-tooth harrows until it was fine enough for a garden. He used a wheelbarrow seeder and covered the seed with a weeder.

His soil is a fairly stiff clay for the first two and one-half feet with the exception of the surface foot, which is in a fine physical cndition because of the organic matter incorporated with it. Below two and one-half feet it becomes more porous because of the fine gravel and sand which appears at that depth. His soil is all underlaid with limestone rock at from two to four or five feet in the large field and four or five feet in the twenty-one acre field.

Mr. Councilman thinks that every farm in the State can be made to grow alfalfa successfully and that the reasons for failures are chiefly because the land has not been properly prepared or the seed put in right. He believes the farmers of this State should grow more legumes, make more manure and use their manure to better advantage in building up the humus exhausted soil so that it will not only produce larger crops of corn and wheat, but will furnish an ideal home for bacterial life and for the growth of alfalfa and red clover. This procedure, together with good tillage, will fit any well drained land for raising large crops of alfalfa.

Mr. Chas. Fairbanks, Royal Oak, Maryland, is growing alfalfa as a rotation crop. His use of the crop for that purpose was accidental and was brought about as follows: Mr. Fairbanks had followed the practice for some time of sowing red clover in wheat early in the spring, cutting it one year for hay and then plowing it under for corn, making a three year rotation of corn, wheat and clover. About eight or ten years ago he sent to Baltimore for red clover seed but unknowingly received alfalfa. He sowed the seed as usual, and secured one good crop of hay that fall and four crops the next summer. The following spring it was plowed up and put into corn. He found that he had what was called alfalfa, but he liked it so well that he has been using it since instead of red clover. He has no trouble in getting a catch and gets much larger yields than he could with red clover. His soil is naturally adapted to alfalfa and, as sweet clover is common about his place, natural inoculation has been thorough.

Mr. E. E. Scott, Western Run, Maryland, sowed some alfalfa in the fall of 1906, using seed inoculated with nitro culture, and on a part of the field applying inoculated soil sent him by the Experiment Station. On July 12, 1907, he reported as follows: The alfalfa came up nicely and made a similar growth on both parts of the field until about a month before the first cutting. Then the portion which was not inoculated with soil turned yellow in spots and at the first cutting yielded not over one-fourth as much as the other portion of the field. Since the first cutting the part not inoculated with soil has improved very much, lost its yellow color, grown more, and I think will yield one-half as much the second cutting as the soil inoculated plot. Nodules are abundant on the soil inoculated portion, but are found only on a part of the plants in the other portion of the field. I consider alfalfa a success, for the soil inoculated plot made me one and one-half to two tons per acre in the one cutting.

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